LESSONS ON OBJECTS:

AS GIVEN TO CHILDREN

BETWEEN THE AGES OF SIX AND EIGHT,

IN A PESTALOZZIAN SCHOOL,

AT CHEAM, SURREY.

"We daily call a great many things by their names without ever inquiring into their nature and properties, so that, in reality, it is only their names, and not the things themselves, with which we are acquainted."—AIKEN.

SEVENTEENTH EDITION.

SEELEY, JACKSON, AND HALLIDAY, FLEET STREET.
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PREFACE.

PESTALOZZI was peculiarly solicitous that the *idea* of his method of Education should not be confounded with the *form* it might assume. He felt, and strongly felt, the value, the power, and the truth of that *idea;* and highly as he was disposed to appreciate the labours of his disciples in the practical application of it to the work of education, still he saw that they were at best imperfect, incomplete embodyings of the grand and profound conceptions in which he might be said intellectually "to live and move and have his being." The continual appeal which he made from the imperfections of his practice, to the beauty and truth of his principles, contributed perhaps to attach to himself the character of a benevolent visionary, and to his system the charge of impracticability. Much had been written, much had been said, yet little seemed to have been done: for even his own school, miserably conducted in many respects, presented but a cloudy and distorted exhibition of his views. Hence the man of lofty mind and feeling heart quitted Yverdon with a sigh of regret; while the shallow reasoner and self-satisfied *routier* cast a smile of contempt on principles which

he could not discover to be true, in the midst of the disorder that impeded and deformed their development.

Profoundly convinced of the truth of Pestalozzi's views, and warned against his errors by long actual observation of their consequences, the writer of these prefatory remarks determined to attempt the introduction of his method into England, religiously preserving the *Idea*, but adapting the *Form* to those circumstances in which he might be placed. He considered that the most effectual mode of accomplishing this end was to devote himself to the formation and conduct of a school, in which the arrangement and practical application of those principles might be made. To exhibit the system in operation, to elaborate by means of experiments continually repeated a course of instruction; and above all to prepare materials for an appeal to actual results, seemed to him a far more useful and effectual, though less rapid or brilliant process, than that of dragging it before reluctant audiences at public meetings, or of advocating its merits in the periodical publications of the day. He was content that it should be buried in oblivion for a while, assured that if it really possessed the life of truth, it would in due time spring up with renovated vigour. That time seems to have arrived. Attention to this subject is revived. Schools professing to be conducted on Pestalozzian principles are increasing in number: and publications issue from the press which point out, with more or less

success, the manner of applying them to different branches of instruction. Under these encouraging circumstances, it is proposed to publish, from time to time, a number of little treatises of a strictly practical nature, embodying in a familiar manner the principles of Pestalozzi. They will be the result of many years' experience—the corrected and recorrected editions of lessons actually given by different individuals. They may want some of that ideal beauty discernible in works produced by an ingenious imagination in the closet; but they will possess, on the other hand, the solid advantage of ascertained practicability and demonstrated usefulness.

It has been thought desirable to commence the series with a course of LESSONS ON OBJECTS. It is a field hitherto little, if at all, cultivated. The distinguishing principles of the Pestalozzian system are strikingly exemplified in it. The instruction given in Infants' Schools would be improved by the introduction of a similar plan, and the early education of the nursery receive a new and interesting feature.

This mode of instruction was suggested to the mind of Pestalozzi by the peculiar circumstances in which he was placed at Stantz. The brutalised state into which the poor children confided to his care had fallen, rendered it absolutely necessary to find some new mode of interesting their minds, and calling out their dormant faculties. Nature was the only book with which they were conversant, and their first les-

sons were consequently drawn from its pages. Experience and judgment retained what necessity first imposed. The subjects ordinarily presented to the youthful mind appeared too remote from that knowledge which the child acquires without regular instruction, and generally to be taught in too abstract a manner. It was proposed to bring education more into contact with the child's own experience and observation, and to find in *him* the first link in the chain of his instruction. In the execution of this plan, a series of engravings was provided, representing those objects which are familiar to children; and the lessons consisted in naming their parts, describing their structure and use. One day, however, the Master having presented to his class the engraving of a ladder, a lively little boy exclaimed, "But there is a real ladder in the court-yard; why not talk about it rather than the picture?" "The engraving is here," said the Master, "and it is more convenient to talk about what is before your eyes than to go into the court-yard to talk about the other." The boy's observation, thus eluded, was for that time disregarded. Soon after, the engraving of a window formed the subject of examination; "But why," exclaimed the same little objector, "why talk of this picture of a window, when there is a real window in the room, and there is no need to go into the court-yard for it?" Again the remark was silenced, but in the evening both circumstances were mentioned to Pestalozzi. "The boy is right," said he; "the

reality is better than the counterfeit: put away the engravings, and let the class be instructed by means of real objects." The plan was adopted; but many inconveniences resulted from the arrangement. The subjects which the room itself, the building, the premises, presented, were soon exhausted, or thought to be so: the pupils were taken into the fields; the weather was an occasional hindrance, the variety of objects presented out of doors distracted the attention of the pupils, and though much interest was at first excited, still, as there was no sensible progress no perceivable end, it diminished rather than increased in force. It was thought, too, that exercises so miscellaneous in their character, so devoid of systematic arrangement, were essentially defective as means of intellectual development. Upon these grounds the Miscellaneous Object Lessons were abandoned, and the Master who had conducted the class substituted a course on the parts and functions of the bodily frame. These are contained in the *Manuel des Mères;* a work presenting valuable hints for early education, mixed with much that is insufferably tedious. At the period when the writer of these observations was in the institution at Yverdon, instructing on objects had fallen into disuse; but having heard this history from the individual who had formerly given it, he felt strongly convinced that a mode might be adopted by which its advantages would be secured, and its contingent inconveniences avoided. Having communicated this impression to

his sister, with a general notion of the plan, he has left the execution of the details to her, and the result of her labours is the Exercises, now for the first time presented to the public. The desultory character attaching to them in their original form is corrected, by making a previous selection of subjects, and presenting them in the class-room. As they are intended to be preparatory to instruction in natural history, they gradually assume a more scientific character, and thus a feeling of progress is sustained in the pupil's mind. It has been found, indeed, by long experience, that no lessons produce more continued interest, or more enlarge the minds of children, than those on OBJECTS.

C. MAYO.

PREFACE

TO

THE FOURTEENTH EDITION.

When this work was first presented to the public, nearly thirty years since, the idea of systematically using the material world as one of the means of educating the minds of children, was so novel and untried a thing in England, that the title "Lessons on Objects" excited many a smile, and the success of the little volume was deemed to be, at best, very dubious. The plain sound sense of the plan, however, soon recommended it to our Teachers, and they discovered that reading, writing, and arithmetic, do not form the sole basis of elementary education, but that the objects and actions of every-day-life should have a very prominent place in their programme.

In spite of the ominous forebodings which attended the first introduction of this little volume, the public has given a decided sanction to the system of teaching it, and the degree in which it has in consequence modified books for the young, and the practice of elementary instruction, can scarcely be calculated.

Successive editions of the Lessons have issued rapidly from the press, hitherto without any alteration; but it is now thought desirable to profit by the experience gained by the introduction of such a course of instruction, and to make a few changes and additions. As the work is much used in institutions for the training of Teachers, the following account of the plan of the whole course is given as a guide in the use of the lessons, and a help in carrying out the idea. Those who fall into a mechanical way of giving such instruction, and do not perceive the principle involved, completely defeat its intention, and they had far better keep to old plans and old books.

The work contains progressive series of lessons, the prevailing aim being to exercise the faculties of children according to their natural order of development, aiming also at their harmonious cultivation.* The first series chiefly exercises the perceptive faculties, arresting attention on qualities discoverable by the senses; and then furnishing a vocabulary to clothe the ideas, and so fixing them in the mind, where they will be ready for reproduction when the faculty of conception begins to act. The second and third series, in addition to this, exercise the conceptive powers in recalling the impressions made upon the senses by external objects, when they are removed from observation—also in leading from what has become known to what is unknown. In the fourth

* See "Home Education," p. 198.

series, the children are exercised in tracing resemblances and differences, in drawing comparisons and recognising analogies, thereby cultivating the power of arranging and classifying.

In the fifth series, the reason and judgment are brought into activity; in tracing the connexion between cause and effect, between use and adaptation; language or the power of expression is cultivated; the ideas developed in the lessons of the previous series are expressed either in simple words or short sentences; but throughout this series the pupils are required to put down all the knowledge they acquire, in the form of consecutive narrative. This plan promotes fixedness of attention during the giving of the lesson, a clear apprehension of facts and truths, and facility in arranging and expressing what has been acquired.

An objection has been made to these lessons, that they put fine words into children's mouths, and give them an air of pedantry—but the evil in reality is the effect of the ignorance that has hitherto prevailed as to the properties of the most common things by which we are surrounded, and the consequent poverty of the poor man's language. When the love of knowledge is excited, and the habit of intelligent observation cultivated, words and phrases are required to define accurately what so often otherwise remains vague impressions on the mind; consequently a more extended vocabulary is requisite, and when no simple and common words can be found to express (for in-

stance, such very important and common qualities as opacity and transparency), the only terms our language affords must be used, and the reproach of pedantry be risked.

Teachers making use of these lessons are earnestly advised to read carefully the introduction to a series before they commence the lessons which it contains, and to endeavour to understand, and then to act up to the principles and aim set forth. They should guard against mere mechanical work, or allowing this in their pupils; the latter, after having heard a few names, will often, without thought or observation, apply them indiscriminately. Neither should the lessons be slavishly followed in all that is set down: they should rather be used as affording suggestive hints; and variety should be sought for—the children often themselves indicate what their minds require.

ELIZABETH MAYO.

Hampstead, July 1855.

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LESSONS ON OBJECTS.

FIRST SERIES.

INTRODUCTORY REMARKS FOR THE DIRECTION OF THE TEACHER.

To lead children to observe with attention the objects which surround them, and then to describe with accuracy the impressions they convey, appears to be the first step in the business of education.

As the period of childhood is characterized by the ceaseless activity of the perceptive faculties, it is clear that with them intellectual education should commence. The development of these powers gives animation to the dull, and precision to the lively, whilst it promotes that clearness of apprehension which is the solid basis of after attainment, and without which our judgments are unsound, and our reasonings inconclusive. As the sphere of observation is enlarged, and the pages of history, or the fields of science, are explored, the mind, accustomed to accurate investigation, will not rest content with

less than satisfactory evidence, either in morals or in science.

The present work consists of five series of lessons, each of which increases in difficulty as the pupil advances. The order observed in them is the result of some experience, and of several trials, which have produced a strong conviction of the importance and value of a methodical arrangement, and of a very gradual progression. It is therefore recommended that no step in the course should be altogether omitted, though the age and talents of the children must regulate the time bestowed on each.

The first series presents a selection of miscellaneous objects, every one possessing some distinguishing quality, and so arranged as to have an obvious connexion with what has preceded. The children should be practised in remarking the qualities observable by the simple operation of the external senses, deferring till a more advanced period those requiring a higher exercise of mind.

It is very important that in all instruction, some definite object should be proposed, and that every step should have a tendency towards the end in view. Thus in the series under consideration, the development of the perceptive faculties is aimed at, and each sense is called into action, that all may be strengthened by exercise, and their judgments corrected. By linking also the ideas gained to appropriate words, a ready command of language may be acquired.

One lesson is drawn out fully as a specimen of the manner in which the others should be given. It would have extended the volume to an unnecessary length, and filled it with needless repetitions, had each been made out with equal minuteness. Information is not given in the preliminary set, as the end proposed is to excite the mental powers of the children to activity, and not to furnish them with knowledge.

It may perhaps be necessary to guard against the error of expecting, in a work like the present, anything more than hints as to the mode of arranging and imparting knowledge. Teachers ought to be well informed, in order to meet the inquiries which the active minds of children continually suggest. Their questions will generally point out the best mode of treating a subject, or of leading them to the discovery of any truth. Precise unvarying rules may be laid down for mechanical operations; but mind alone can act upon mind, and bring it into vigorous exercise; and all instruction must be dry and uninteresting, which has not undergone some modification from the person by whom it is communicated.

There are several faults into which teachers are likely to fall; one is that of telling too much, for though the information may be received with pleasure, and appear to profit, yet under such a mode of instruction, the pupils' minds remain almost passive, and they acquire a habit of receiving impressions from others, at a time when they ought to be

gaining mental power by the exertion of their own faculties. Another mistake is that of giving a term, before the pupil has felt his want of it.* When the idea of any quality has been formed in his mind, without his being able to express it, the name given under such circumstances fixes it on the memory:—thus, when a child observes that whalebone, after having been bent, returns to its original position, he may be told that this property which he has discovered is called *elastic.*

The following pages were written originally with no view to publication, but merely for the use of the school in which they were given; and the information they contain was drawn from various sources. No memorandum being made at the time, it would now be impossible to assign passages to their different authors, though it is probable that those acquainted with the popular works on the subjects here treated of, may detect, in some places, almost literal quotations.

* The writer desires particularly to enforce this remark, having in one or two instances seen the lessons altogether misused.—Thus the qualities were told, and the explanation of the terms given, instead of the object being presented to the children that they might make their own observations upon it, and learn from the teacher how to express qualities clearly discerned by them, although unknown by name.

LESSON I.

GLASS.

GLASS has been selected as the first substance to be presented to the children, because the qualities which characterize it are quite obvious to the senses. The pupils should be arranged before a black board or slate, upon which the result of their observations should be written. The utility of having the lessons presented to the eyes of the children, with the power of thus recalling attention to what has occurred, will very soon be appreciated by the instructor.

The glass should be passed round the party, to be examined by each individual.*

TEACHER. What is this which I hold in my hand?

CHILDREN. A piece of glass.

TEACHER. Can you spell the word *glass?*

(The teacher then writes the word "glass" upon the slate, which is thus presented to the whole class as the subject of the lesson.) You have all examined this glass; what do you observe? What can you say it is?†

* By this means, each individual in the class is called upon to exercise his own powers on the object presented; the subsequent questions of the teacher tend only to draw out the ideas of the children, which he corrects if wrong.

† This question is put instead of asking, "What are its

CHILDREN. It is bright.

TEACHER. (The teacher having written the word "qualities," writes under it—It is bright.) Take it in your hand and *feel** it.

CHILDREN. It is cold. (Written on the board under the former quality.)

TEACHER. Feel it again and compare it with the piece of sponge that is tied to your slate, and then tell me what you perceive in the glass.†

CHILDREN. It is smooth—it is hard.

TEACHER. What other glass is there in the room?

CHILDREN. The windows.

TEACHER. Look out at the window and tell me what you see.

CHILDREN. We see the garden.

TEACHER. (Closes the shutters.) Look out again, and tell me now what you observe.

CHILDREN. We cannot see anything.

TEACHER. Why cannot you see anything?

CHILDREN. We cannot see through the shutters.

qualities?" because the children would not, at first, in all probability, understand the meaning of the term; its frequent application, however, to the answer to this question will shortly familiarise them to it, and teach them its meaning.

* The art of the teacher is to put such questions as may lead successively to the exercise of the different senses.

† The object of the teacher here is to lead the pupil to the observation of the quality *smooth*, and he does so by making him contrast it with the *opposite* quality in another substance; a mode of suggestion, of which frequent use may be made.

TEACHER. What difference do you observe between the shutters and the glass?

CHILDREN. We cannot see through the shutters, but we can through the glass.

TEACHER. Can you tell me any word that will express this quality which you observe in the glass?

CHILDREN. No.

TEACHER. I will tell you, then; pay attention, that you may recollect it. It is transparent.* What shall you now understand when I tell you that a substance is transparent?

CHILDREN. That you can see through it.

TEACHER. You are right.† Try and recollect something that is transparent.

CHILDREN. Water.

TEACHER. If I were to let this glass fall, or you were to throw a ball at the window, what would be the consequence?

CHILDREN. The glass would be broken. It is brittle.

* The fact of the glass being transparent is so familiar to the children, they will probably not observe it till its great use in consequence of that quality brings it forcibly before their minds. They then feel the want of a term to express the idea thus formed, and the teacher gives them the name, as a sign for it, and in order to impress it upon their minds. To ascertain whether they have rightly comprehended the meaning of the word, they are called upon to give examples of its application.

† It is but too common a practice to call a child *good* because he gives a right answer; thus confounding intellectual truth and moral virtue.

TEACHER. If I used the shutter in the same manner, what would be the consequence?

CHILDREN. It would not break.

TEACHER. If I gave it a sharp blow with a very hard substance, what would happen?

CHILDREN. It would then break.

TEACHER. Would you, therefore, call the wood brittle?

CHILDREN. No.

TEACHER. What substances, then, do you call brittle?

CHILDREN. Those which are *easily* broken.

These are probably as many qualities as would occur to children at their first attempt: they should be arranged on the slate, and thus form an exercise in spelling. They should then be effaced; and if the pupils are able to write, they may endeavour to remember the lesson, and put it down on their slates.

LESSON II.

INDIAN RUBBER.

This substance has been chosen that the class may observe the qualities,—*opaque*, *elastic*, *inflammable*. The first would be made clear to them by contrasting the Indian Rubber with the Glass of the preceding lesson; the second by stretching it, and allowing it to resume its former shape; the third, by setting it on fire.

Qualities of Indian Rubber.

It is opaque.
elastic.
inflammable.
black.
tough.
smooth.

Uses.—To rub out pencil-marks; to make balls.

LESSON III.

LEATHER.

Ideas to be developed by the examination of this substance,—*flexible*, *odorous*, *durable*.

Qualities of Leather.

It is flexible.
odorous.
waterproof.
tough.
smooth.
durable.
opaque.

Uses.—For shoes; gloves; reins; saddles; portmanteaus; binding books.

LESSON IV.

LOAF-SUGAR.

Ideas to be developed by this lesson,—*soluble, fusible, sparkling.*

Qualities of Loaf-Sugar.

It is soluble.
fusible.*
brittle.
hard.
sweet.
white.
sparkling.
solid.
opaque.

Use.—To sweeten our food.

* The difference between fusibility and solubility may be rendered obvious to the children, by dissolving one piece of sugar in water, and holding another over the candle. It is better that such simple experiments should be performed in their presence, than that a mere description of the operation should be given.

LESSON V.

A PIECE OF GUM ARABIC.

Ideas to be developed by this lesson,—*semi-transparent, adhesive.*

Qualities of Gum Arabic.

It is hard.
bright.
yellow.
semi-transparent.
soluble in water.
adhesive when melted.
solid.

Use.—To unite light and thin substances.

LESSON VI.

SPONGE.

Ideas to be developed by this lesson,—*porous, absorbent.*

Qualities of Sponge.

It is porous.
absorbent.*

* The quality of absorbing will be made obvious to the

It is soft.
tough.
opaque.
elastic.
dull.
flexible.
light brown.

Use.—For washing.

LESSON VII.

WOOL.

Qualities of Wool.

It is soft.
absorbent.
white.
flexible.
elastic.
tough.
durable.
opaque.
dry.
light.

Uses.—For making cloth; flannels; blankets; carpets; stockings; &c.

class by showing that the sponge sucks up any liquid. It possesses this quality in consequence of its being full of pores. The use to which an object is applied, often leads to the observation of the quality upon which the use is dependent.

LESSON VIII.

WATER.

Ideas to be developed by this lesson,—*liquid, reflective, glassy, tasteless, inodorous.*

Qualities of Water.

It is liquid.
reflective.
glassy.
colourless.
inodorous.*
tasteless.
transparent.
heavy.
bright.
wholesome.
purifying.

Uses.—To cleanse; to fertilize; to drink; for culinary purposes.

* In order to direct the attention of the class to the force of the syllables *less* and *in*, the teacher should ask,—What is meant by taste*less*? Having no taste. What is meant by *in*odorous? Having no odour. In what are these words alike? They both tell us what the substance is not. They mark then the absence of a quality. What syllables of the words mark this absence of the quality? *less* and *in*. Give examples of words in which *less* and *in* are so used.

LESSON IX.

A PIECE OF WAX.

This substance is here introduced, because it possesses many of the qualities already remarked.

Qualities of Wax.

It is solid.
opaque.
dull.
tough.
fusible.
sticky.
yellowish.
hard.
odorous.
smooth.

Use.—To make candles and tapers.

LESSON X.

CAMPHOR.

Ideas to be developed by this lesson,—*aromatic, friable, volatile.*

Qualities of Camphor.

It is aromatic.
easily crumbling, or friable.

It is white.
semi-transparent.
bright.
soluble in spirits.
hard.
solid.
very inflammable.
medicinal.
light.
volatile.

Uses.— For medicine; to prevent infection; to preserve cabinets from small insects.

LESSON XI.

BREAD.

Ideas to be developed by this lesson,— *edible*, *wholesome*, *nutritious*.

Qualities of Bread.

It is porous.
absorbent.
opaque.
solid.
wholesome.
nutritious.
edible.
The crumb is yellowish white.
soft, when new.
moist.

The crust is hard.
brittle
brown.

Use.—To nourish.

LESSON XII.

SEALING-WAX.

Idea to be developed by this lesson,—*impressible.*

Qualities of Sealing-Wax.

It is hard.
bright.
brittle.
fusible.
opaque.
soluble in spirits.
light.
solid.
smooth.
coloured.*
inflammable.
odorous.
When fused it is soft.
impressible.
adhesive.

Use.—To seal letters.

* The colour will be determined by the specimen presented.

LESSON XIII.

WHALEBONE.

Idea to be developed by this lesson,—*fibrous*

Qualities of Whalebone.

It is elastic.*
durable.
hard.
fibrous.
opaque.
bright.
stiff.

Uses.—As a stiffener; for whips, bludgeons, &c.

LESSON XIV.

GINGER.

Idea to be developed by this lesson,—*pungent.*

Qualities of Ginger.

It is pungent.
dull.
hard.

* The class should be led to compare the elasticity of Whalebone with that of Indian Rubber, and to observe the difference of the quality; the former when bent returns to its original shape. The Indian Rubber, when stretched, does so; and many substances, as sponge, after compression, resume their shape.

It is dry.
fibrous.
aromatic.
tough.
opaque.
wholesome.
medicinal.
jagged.
light brown.

Uses.—To flavour food ; for medicine.

LESSON XV.

BLOTTING-PAPER.

Idea to be developed by this lesson,—*pinkish.**

Qualities of Blotting-Paper.

It is absorbent.
porous.
soft.
thin.
pinkish.
pliable.
dull.
inflammable.
easily torn.

Use.—To suck up superfluous ink.

* *Ish*, added to words expressive of quality, generally denotes the presence of the quality, but in a moderate degree.

LESSON XVI.

A PIECE OF WILLOW.

Qualities of Willow.

It is hard.
inflammable.
fibrous.
dull.
opaque.
solid.
elastic.
flexible.
white.
odorous.

LESSON XVII.

MILK.

Qualities of Milk.

It is white.
liquid.
opaque.
soft.
wholesome.
greasy.
nutritious.
sweet.

Uses.—To make cheese; butter; puddings; to drink; food for young animals.

LESSON XVIII.

RICE.

Qualities of Rice.

It is white.
hard.
opaque.
smooth.
stiff.
bright.
solid.
porous.
absorbent.
wholesome.
nutritious.

Use.— To nourish.

LESSON XIX.

SALT.

Ideas to be developed by this lesson,— *granulous, sapid, saline.*

Qualities of Salt.

It is white.
sparkling.
granulous.

It is sapid, or has taste.
salt, or saline.
hard.
opaque.
soluble.
fusible.

Uses.—To flavour food; to preserve from putrefaction; to manure land.

LESSON XX.

A HORN.

Qualities of a Horn.

It is hard.
dull.
uneven.
hollow.
odorous when burnt.
tapering.
opaque.
stiff.
yellowish brown.
fibrous.

Uses.—To make combs; glue; lanterns; handles to knives and forks.

LESSON XXI.

IVORY.

Qualities of Ivory.

It is hard.
white.
smooth.
bright.
opaque.
solid.
durable.

LESSON XXII.

CHALK.

Idea to be developed by this lesson,—*effervescent.*

Qualities of Chalk.

It is white.
friable.
effervescent in acids.*
opaque.
dull.
hard.
solid.
dry.

* This quality may be made apparent to the children by putting chalk in vinegar.

LESSON XXIII.

A PIECE OF THE BARK OF THE OAK-TREE.

Idea to be developed by this lesson,—*astringent.*

Qualities of Bark.

It is brown.
rugged.
opaque.
dry.
inflammable.
stiff.
solid.
durable.
fibrous.
dull.
astringent.*
inside smooth.

Uses.—To guard the tree from injury; for tanning.

* The children may be made to understand the quality of astringency, by drawing their attention to the contracting effect produced in the mouth by eating a sloe.

SECOND SERIES.

INTRODUCTORY REMARKS FOR THE DIRECTION OF THE TEACHER.

In this series the children should be much exercised upon the *qualities* already remarked, but presented to them in other *objects*. This recurrence of the same qualities, as seen in different substances, combines, with the advantage of fixing the knowledge they have acquired,—that of enabling them to form the abstract idea of the quality.

The impressions made upon the senses by external objects return to the mind in the absence of the objects. This is the simplest working of the conceptive faculty, and it should find exercise in this and the following series. Thus, when a distinguishing quality is observed, the children should be directed in searching in their own minds for the idea of some other object in which they had before recognised the same quality.

Care should be taken by instructors when they wish, in the first instance, to develope the idea of a quality, to select a substance in which it is very conspicuous; and, secondly, when giving a lesson on an object in which the same quality recurs, to advert

to former impressions. The distinctness and force of our ideas, and their firm hold on our minds, depend on the vividness and clearness with which they were first apprehended, and on the reiterated recurrence of the same impressions.

Having had all their senses brought into action in former lessons, the children may be led to determine the *sense* by the exercise of which any particular property was observed: thus, 'How did you find out that glass was transparent? 'By my eyes.' 'What can you do with your eye?' 'See.' '*Seeing* is called a *sense*. Can you obtain an idea of a quality except by the sense of sight? Will your sight discover to you that a rose is odorous? How would you ascertain this quality?' 'By what sense?' 'By smelling. By the sense of smell.' By similar questions the class will gain a clear conception of the several *senses* and their operations. They may next proceed to the observation of the *organs* of sense. Thus, 'By what natural instruments are you able to see, hear?' &c. 'By eyes, ears,' &c. Any natural instrument by which something is performed, is called an *organ*. 'What are the eyes?' 'Organs.' 'Organs of what sense?' 'Organs of sight,' &c.

It will be a useful exercise for the children to classify the various *qualities*, which they have observed in objects, under the heads of the different *senses* by which they are discerned. They will soon perceive that some may be discovered by either of two senses; for example, *liquid*, *solid*, *rough*, and

the varieties of form may be ascertained either by *sight* or *feeling;* these should constitute another division. Thus trained to arrange their ideas, children will acquire a great readiness in making use of their information, and a facility in producing new combinations.

No one who has not given little children such lessons can be aware of the great pleasure experienced by them, when they first discover the power which they possess of acquiring knowledge through the exercise of their senses; and also of the systematic order it gives to their subsequent acquisition of knowledge.

In this series, children may also be practised in distinguishing and naming the *parts* of objects; while this helps them to form a more correct idea of particular things, it also prepares them to discriminate between substances and qualities.

There are two errors which teachers are apt to fall into, especially in the early lessons. First, after a few lessons on parts and qualities, they do not correct the children when they get into the habit of attributing qualities of which they have learnt the names, indiscriminately to all objects without thought. Secondly, Teachers do not make any effort to fix the attention of the children in distinguishing between general and peculiar qualities.

LESSON I

A PIN.

A pin has been chosen for the first lesson, because the parts are few, clearly marked, and simple.

Parts.	*Qualities.*
The head.	It is hard.
shank.	opaque.
point.	white.
	bright.
	solid.
	smooth.
	cold.
	The head is round.
	The point is sharp.
	The shank is straight.
	taper.

Use.—To keep together for a time parts of dress, &c.

LESSON II.

A CUBE OF WOOD.

The cube will convey to the children a good idea of a *surface;* but as some confusion is likely to arise in their minds, when they are informed that what bounds every part of an object, and can be felt or seen, is the *surface*, and then when they find

that the surface is divided into parts, to be told that these divisions are called surfaces, it is therefore necessary to give them a name for the divisions of the surface—that of *faces* has been adopted. A sphere may be shown as an example of an undivided surface, and, by comparing it with the cube, a clear idea of what is meant by *surface* and *faces* may be elicited.

Parts.	*Qualities.*
The surface.	It is hard.
faces.	light.
edges.	solid.
corners.	brown.
	smooth.
	dull.
	inflammable.
	opaque.
	The faces are flat.
	square.
	The edges are straight.
	The corners are sharp.

LESSON III.

AN UNCUT LEAD-PENCIL.

From this object the children may become acquainted with the *cylinder*; for they will not fail to observe that the ends are flat, and that the other face is curved.

Parts.	*Qualities.*
The surface	It is hard.
faces.	odorous.
ends.	long.
outside.	solid.
inside.	opaque.
middle.	nflammable.
lead.	dry.
wood.	brown.
	veined.
	One face is curved.
	The ends are flat.
	circular.
	The form is cylindrical.
	The lead is grey.
	brittle.
	friable.
	bright.

Uses.—For writing; drawing, &c. Let the children point out on what occasion a pencil is preferable to a pen, and *vice versâ*.

In this lesson and others, the conceptive faculty may be exercised, by requiring the children to recall to their minds some object in which they had observed before the quality of inflammability; also that of friability.

LESSON IV.

A PEN.

A pen presents many different *parts;* the *qualities* of some of these are opposite to the *qualities* of others.

Parts.	*Qualities.*
The quill.	The quill is transparent.
shaft.	cylindrical.
feather.	hollow.
laminæ.	bright.
pith.	hard.
nib.	elastic.
split.	yellowish.
shoulders.	horny.
surface.	The shaft is opaque.
faces.	angular.
skin.	solid.
groove.	white.
inside.	stiff.
outside.	hard.
	grooved.
	The pith is white.
	spongy.
	porous.
	elastic.
	soft.

LESSON V.

A WAX-CANDLE.

This object recalls the idea of the *cylinder*, obtained in a previous lesson, and presents the peculiar *parts* of the candle itself.

Parts.	*Qualities.*
The wick.	It is cylindrical.
wax.	hard.
surface.	opaque.
faces.	yellowish white.
ends.	The wax is sticky.
edges.	fusible.
top.	The wick is inflammable.
bottom.	tough.
middle.	white.
inside.	fibrous.
outside.	flexible.

Use.—To give light.

The children should be asked, What must be done before the candle gives light? What becomes of the wick? What of the wax?

LESSON VI.

A CHAIR.

This, and several of the succeeding lessons, are

chosen on account of the great variety of the *parts* of the object.

Parts.

The back.
front.
seat.
top.
bottom.
frame.
legs.
straw.
edges.
upper part of the seat.
under part of the seat.
bars.
surface.
faces.
corners.

The *qualities* are not set down, because they depend upon the kind of chair chosen for the lesson.

It is a useful exercise to compare the relative proportions and situations of the different parts of an object. Thus, in the chair, the depth of the seat is about one-half the height of the chair; the legs are rather shorter than the back; the seat is narrower at the back than the front; &c. The legs are perpendicular, the seat horizontal, the back slanting, the bars horizontal and parallel.

LESSON VII.

A BOOK.

Parts.

The outside.
inside.
edges.
corners.
binding.
paper.
back.
sides.
top.
bottom.
title-page.
preface.
introduction.
contents.
end.
leaves.
pages.
margin.
beginning.
type.
letters.
numbers.
stops.
words.

The sentences.
syllables.
lettering.
stitching.
lines.

The children should determine the position of the different parts, their form and uses.

LESSON VIII.

AN EGG.

Parts.	*Qualities.*
The shell.	It is oval.
skin.	white.
white.	hard.
yolk.	eatable.
outside.	nutritious.
inside.	opaque.
surface.	dull.
embryo, or future chicken.	The shell is brittle.
	smooth.
	thin.
	translucent.
	The white is liquid when raw.
	solid when boiled.
	semi-transparent.
	adhesive.
	sticky.
	insipid.

The yolk is yellow.
liquid.
soft.
opaque.
odorous.
sapid.

LESSON IX.

A THIMBLE.

Parts.	*Qualities.*
The inside.	It is hollow.
outside.	silver.
surface.	punctured.
top.	white.
bottom.	bright.
rim.	opaque.
border.	hard.
punctures.	curved.
	The inside is smooth.
	The outside is rough.

Use.—To preserve the middle finger from being pricked in working.

LESSON X.

A PENKNIFE.

Parts.	*Qualities.*
The handle.	The blade is steel.

The blade.	The blade is bright.
plates.	cold.
grooves.	hard.
back of the handle.	reflective.
back of the blade.	opaque.
point.	brittle.
edge.	The front edge is thin.
notch.	sharp.
spring.	The back edge blunt.
rivets.	thick.
pivot.	The handle is hollow to receive the blades.
heel.	flat.

Use.—To mend pens, &c.

The other qualities depend upon the kind of knife shown. The children should mention what kind of knives they know of, and what other instruments are used in cutting.

LESSON XI.

A KEY.

Parts.	*Qualities.*
The ring.	It is hard.
barrel.	steel.
wards.	bright.
grooves.	cold.
edges.	opaque.
surface.	smooth.
corners.	stiff.

It is liable to rust.
Part of the barrel is hollow.
The barrel is cylindrical.
The ring is curved.

Places locked up by a key.—Doors, gates, boxes, desks, portmanteaus, trunks, portfolios, tea-chests, closets, drawers, cabinets, &c.

LESSON XII.

A CUP.

Parts.	*Qualities.*
The bowl.	It is hollow.
handle.	hard.
upper rim.	curved.
lower rim.	glossy.
bottom.	smooth.
inside.	glazed.
outside.*	cold.
edges.	brittle.
surface.	thin.
	semi-transparent.

The rim is circular.

* From the examination of such an object as a cup, glass, any vessel, or a box, children may be led to discriminate clearly the difference between outside and surface, and to see that the former is the opposite to the inside, whilst the latter is the boundary of every part of an object.

LESSON XIII.

A COFFEE BERRY.

Parts.	*Qualities.*
The surface.	If roasted, it is brown.
curved face.	hard.
flat faces.	crisp.
groove.	sapid.
	aromatic.
	stimulating.
	agreeable to the taste.
	dull.
	solid.
	If unroasted, dingy yellow.
	inodorous.
	disagreeable to the taste.

Use.—To make a beverage.

Children should determine what other object they have found to be aromatic.

LESSON XIV.

A PAIR OF SCISSORS.

Parts.	*Qualities.*
The limbs.	It is steel.

The bows.	It is bright.
blades.	reflective.
shanks.	hard.
rivets.	opaque.
pivot.	cold.
points.	solid.
surface.	The blades are pointed.
faces.	One face is flat.
	the other curved.
	The front edge sharp.
	the back blunt.
	The bows are curved.

The children should name the kind of materials which scissors will cut, and point out the different manner in which knives and scissors cut.

LESSON XV.

A BIRD.

Parts.

The head.
body. } Principal
wings. } parts.
legs. }
beak.
eyes.
nostrils.
neck.
feathers.

The qualities would depend on the kind of bird chosen for the lesson.

The skin.
bones.
feet.
claws.
joints.

The children should determine which are the parts that distinguish it as a bird,—feathers, beak, wings; they should state why wings are necessary for birds; why feathers are the best covering for them; why it has a beak; what it has in place of fore-legs; how claws are suited to it.

LESSON XVI.

AN ORANGE.

Idea to be developed,—*spherical.*

Parts.	*Qualities.*
The peel.	It is reddish yellow, or orange colour.
rind of the peel.	spherical.
white of the peel.	rough on the outside.
juice.	
pulp.	
pips.	The pulp is juicy.
eye.	soft.
divisions.	cooling.
membrane.	sweet when ripe.
inside.	odorous.
outside.	vegetable.
surface.	opaque.
	solid.

THIRD SERIES.

INTRODUCTORY REMARKS FOR THE DIRECTION OF THE TEACHER.

In this series the children may be led to the observation of *qualities* which cannot be discerned merely by the senses. Thus by showing them at the same time wool and woollen cloth, and questioning them as to the difference of the two, they will readily conceive the ideas of *natural* and *artificial*. In this manner they may be led to remark the distinction between *foreign* and *native; exotic* and *indigenous; animal, vegetable, mineral, &c.*

At this step the conceptive powers should be more decidedly called into exercise; the way for this is prepared by the clearness and vividness of the ideas obtained through the careful cultivation of perception. Our hints for instruction may be arranged, as Isaac Taylor suggests, under three heads, —"The first comprehending what relates to the means proper for giving vivacity and precision to the conceptive faculty, *while the objects upon which it is employed are actually present.* The second, including whatever bears upon its operation *in the absence of those objects.* And the third, embracing the means

to be used for establishing a ready and perfect correspondence between *language* and the conceptive faculty."

The children may now be called upon to give an explanation of the terms they use, and be assisted by the teacher to trace their derivations.

LESSON I.

A QUILL.

Ideas to be developed by this lesson,—*natural*, *artificial*, *animal*, *vegetable*. A pen should be shown at the same time with the quill; and the children, being questioned as to what constitutes the essential difference between the two, will understand the terms *natural* and *artificial*. If some fruits or flowers be placed near the quill, their attention may be directed to the distinction between *animal* and *vegetable* substances.

Parts.	*Qualities.*
The quill.	It is long.
shaft.	stiff.
ends.	useful.
feather.	natural.
laminæ.	animal substance.
inside.	The barrel is transparent.
outside.	hard.
edges.	elastic.
groove.	bright.

The surface.
faces.
pith.
skin.

The barrel is yellowish.
cylindrical.
hollow.
light.

The shaft is feathered.*
white.
stiff.
hard.
opaque.
solid.
angular.
grooved.

Children may be led to remark the difference which fire produces on animal and vegetable substances, both as to appearance and smell.

The teacher now requires the class to give an explanation in their own words of the terms they have used: and also helps them to trace the derivation of words, and to mark the force of particular syllables.*

TEACHER. Give me examples of words of the same termination as Use*ful*.

CHILDREN. Care*ful*, &c.

TEACHER. What is the force of the termination?

CHILDREN. It expresses the quality in a great degree.

TEACHER. What is the opposite of Use-*ful*?

CHILDREN. Use-*less*.

* The radical or invariable part of the word is printed in Roman characters, the termination in italics.

TEACHER. Give examples of words of the same termination as Use-*less*.

TEACHER. From what is Natural derived?

CHILDREN. Nature.

TEACHER. Transparent is derived from trans, *through*, and par-*ens*, *appearing*.* Give other words derived from Par-*ens*, *appearing*.

CHILDREN. Apparent, Apparition.

TEACHER. From what is Cylindr-*ical* derived?

CHILDREN. From Cylinder.

TEACHER. Cylinder is derived from the Greek κυλινδω (*kylindo*), I roll.

LESSON II.

A HALFPENNY

Ideas to be developed in this lesson,—*mineral*, *metallic*.

Parts.	*Qualities.*
The surface.	It is round.
faces.	flat.
edges.	mineral.
milling.	metallic.
impression.	opaque.
image.	bright.
superscription.	copper.

* The derivations should be written upon the slate, and read over several times by the children.

The reverse.	It is cold.
date.	reddish brown.
	fusible.
	hard.
	odorous.
	artificial.*
	heavy.
	durable.
	uneven.

Made from copper ore, which contains sulphur in union with copper; the sulphur forced off by smelting. Stamped by a die, which is made to fall upon the coin with great violence.

Remarks on Words.

Mine-*ral* is derived from	Mine.
Metal-*lic*	Metal.
Fus-*ible*	To fuse.
Artific-*ial*	Art-*e*, by art; fac-*ere*, to make.
Dur-*able*	Dur-*are*, to last.

TEACHER. Do you know any other words derived from dur-*are*?

CHILDREN. Duration, During, Endure.

* The class should be led to remark that, though the workmanship is artificial, the substance is natural.

LESSON III.

MUSTARD-SEED.

Ideas to be developed by this lesson,—*indigenous*, *pulverable*.

Qualities.

It is pungent.
dull.
yellow.
opaque.
hard.
dry.
pulverable.
natural.
indigenous.
vegetable.
spherical.
solid.
stimulating.

Remarks on Words.

Pung-*ent* is derived from Pung-*ere*, to prick.
Pulv-*erable* . . . . Pulv-*is*, dust.
Indigen-*ous* . . . . Indigen-*a*, a native, or produced in a country.

LESSON IV.

AN APPLE.

Parts.	*Qualities.*
The eye.	It is spherical.
core.	bright.
pips.	odorous.
peel.	coloured.
pulp.	opaque.
juice.	natural.
stalk.	vegetable.
surface.	juicy.
inside.	hard.
outside.	nice.
	solid.
	pleasant.
	The eye is dry.
	brown.
	shrivelled.
	The pips are brown on the outside when ripe.
	white in the inside.
	pointed oval.
	hard.
	bright.
	The core is membranaceous.
	stiff.
	yellow.
	hard.
	semi-transparent

Remarks on Words

Spher-*ical* is derived from Sphere.

TEACHER. Give instances of similar terminations.

CHILDREN. Cylindr-*ical*, Crit-*ical*, Con-*ical*.

Odor-*ous* is derived from *odor*, scent.

TEACHER. Give instances of similar terminations.

CHILDREN. Indigen-*ous*, Nutriti-*ous*.

Veget-*able* is derived from veget-*are*, to grow as a plant.

TEACHER. Name other words derived from this.

CHILDREN. To Vegetate, Vegetation.

Juicy is derived from Juice.

TEACHER. Give some other instances in which the names of qualities are derived from those of substances in a similar manner.

CHILDREN. Stone, ston-*y*; Milk, milk-*y*; Water, water-*y*.

Semi-transparent is derived from *semi*, *trans*, through, and *parens*, *ap*-pear-*ing*.

TEACHER. What is the meaning of *semi*?

CHILDREN. Half.

LESSON V.

GLASS OF A WATCH.

The ideas to be developed by this lesson,—*concave* and *convex*.

*Parts.** *Qualities.*

It is artificial.
transparent.
brittle.
bright.
thin.
hard.
clear.
cold.
curved.
The upper face is convex.
The under face concave.
The edge circular.

Uses.—To preserve the hands of the watch from being injured, and to keep the works from dust.

LESSON VI.

BROWN SUGAR.

The ideas to be developed by this lesson,—*foreign, imported.*

Qualities.

It is brown.
granulous.

* The children should be asked whether there are any parts to this object peculiar to it; and when, as in the watch-glass, there are not, the naming of the parts had better be omitted.

It is sweet.
soluble.
fusible.
opaque.
useful.
vegetable substance.
artificial.
foreign.
sticky.
imported.
moist.

Use.—To sweeten our food.

Obtained from the sugar-cane, which is cultivated in the East and West Indies.

Remarks on Words.

Granul-*ous* is derived from Granul-*um*, a small grain.
Import-*ed* . . . . . Port-*are*, to carry, in, *into*.
Export-*ed* . . . . . Ex, *out*, and port-*are*.
Sol-*uble*, ... Sol-*vere*, to loosen; the particles may be loosened from each other by liquids.

LESSON VII.

AN ACORN.

Parts.	*Qualities.*
The cup.	It is vegetable.

The berry.
nut.
point of the nut.
scar.
scales.
inside.
outside.
surface.
edges.

It is natural.
hard.
green.
opaque.
The nut is oval.
bright.
solid.
The cup is dull.
The inside is convave.
smooth.
The outside is rough.
brownish.
scaly.
The edge is circular.

LESSON VIII.

A PIECE OF HONEY-COMB.

Parts.

The cells.
divisions.
edges.
base of cells.
corners.
surface.
faces.

Qualities.

It is natural.
animal production.
light.
fusible.
sticky.
dull.
semi-transparent.
yellowish.
thin.
compressible.

. It is brittle.
The cells are hexagonal.
regular.
hollow.

LESSON IX.

REFINED SUGAR.

The ideas to be developed by this lesson,—*crystalline, amorphous.*

Parts.	*Qualities.*
The surface.	It is white.
edges.	sweet.
middle.	sparkling.
crystals.	crystalline.
grains.	solid.
pores.	fusible.
	soluble.
	shapeless or amorphous.
	hard.
	refined.
	nutritious.
	friable.
	opaque.
	artificial.
	vegetable substance.
	brittle.

Brought from the East and West Indies in its raw

state. Refined by sugar-bakers, and sold by grocers in loaves of a conical form.

Remarks on Words.

Crystal-*line*, is derived from Crystal.
Amorph-*ous*, ... *a* (*a*) not, μορφη, (*morphé*), shape.
Nutri-*tious* . . . . . Nutri-*re*, to nourish.

LESSON X.

A CORK.

The ideas to be developed by this lesson,—*compressible, meagre to the touch.*

Parts.	*Qualities.*
The ends.	It is light.
surface.	compressible.
faces.	elastic.
edges.	opaque.
middle.	dry.
	meagre to the touch.
	light brown.
	solid.
	porous.
	smooth.
	cylindrical.
	dull.
	inflammable.
	vegetable.

The form is artificial.
The substance is natural.

Uses.—To stop bottles, to buoy people up in the water. Children to determine what qualities fit it for its use.

LESSON XI.

GLUE.

Qualities.

It is translucent.
mahogany brown.
hard.
bright.
solid.
animal substance.
artificial.
When melted, it is tough.
adhesive.
sticky.
elastic.
tenacious.

Remarks on Words.

Ten-*acious* is derived from Ten-*ax*, holding.
Adhes-*ive*, ... Ad, to; and hær-*ere*, to stick.
(perfect, hæsi.)

LESSON XII.

PACKTHREAD.

Qualities.

It is dry.
dull.
twisted.
flexible.
tough.
opaque.
fibrous.
artificial.
durable.
light brown.
vegetable substance.
inflammable.
soft.
slender.
solid.
rough.

LESSON XIII.

HONEY.

Qualities.

It is sweet.
fluid.

It is thick.
liquid.
yellow
bright.
sticky.
vegetable substance.
natural.
nourishing.
healing.
opaque.

LESSON XIV.

BUTTER-CUP.

Parts.	*Qualities.*
The petals.	It is vegetable.
margins or edges.	concave.
cup.	natural.
leafits of cup.	odorous.
stamens.	The petals are yellow.
pistils.	glossy in the inside.
stalk.	dull on the outside.
place of insertion.	circular.
inside.	pointed at the place of insertion.
outside.	striped.
surface.	opaque.
	pliable.

The leafits are greenish.
thin.
membranaceous.
semi-transparent.
pointed.
The stalk is green.
grooved.
angular.
stiff.
fibrous.

LESSON XV.

A LADY-BIRD.

Parts.	*Qualities.*
The head.	It is animal.
eyes.	natural.
feelers, or palpi.	hemispherical.
horns, or antennæ.	The wing-cases are red.
wings.	spotted.
wing-cases, or elytra.	bright.
thorax.	hard.
legs.	brittle.
body.	opaque.
back.	stiff.
spots.	The outside is convex.
surface.	The inside is concave.
margin.	One margin straight.
claws.	The other curved.

The wings are membranaceous.
pliable.
thin.
transparent.
fragile.
The body is oval.
black.
The legs are jointed.
short.
black.

LESSON XVI.

AN OYSTER.

Parts.	*Qualities.*
The valves.	It is animal.
hinge.	opaque.
outside.	marine.
inside.	natural.
margin.	The valves are circular.
impressions.	hard.
mollusc.	stiff.
scales, or laminæ.	pulverable.
	The outside is rough.
	scaly or laminated.
	irregular.
	dull.
	dingy brown.
	uneven.
	The inside is pearly.

The inside is bright.
smooth.
slightly concave.
iridescent.
cold.
The mollusc is soft.
eatable.
nutritious.
cold.
smooth.
lubricious.

Remarks on Words.

Mar-*ine*	is derived from	Mar-*e*, sea.
Lamin-*ated*	. . .	Lamin-*a*, a plate.
Irid-*escent*	. . .	Irid-*escere*, to become like a rainbow.
Lub-*ricious*	. . .	Lub-*ricus*, slippery.

LESSON XVII.

A FIR-CONE.

Parts.	*Qualities.*
The scales.	It is brown.
seeds.	opaque.
top.	hard.
place of insertion.	vegetable.
fibres.	natural.
outside.	conical.

The inside.	It is tiled or imbricated.
surface.	inflammable.
stalk.	odorous.
	The scales are rigid.
	dull.
	The outside is light brown.
	pointed at the top.
	rough.
	irregularly conical.
	The inside of scales is chestnut-colour.
	shaded.
	keeled.

Remarks on Words.

Imbric-*ated* is derived from Imbric-*are*, to cover with tiles.

LESSON XVIII.

FUR.

Parts.	*Qualities.*
The skin.	It is an animal substance.
hair.	It is hairy.
surface.	inanimate.
points of hair.	The hairs are flexible.
	slender.
	soft.
	tubular.
	straight.

The hairs are pointed.
The skin is stiff.

The colour and other peculiarities to be decided by the specimen presented.

LESSON XIX.

A LAUREL LEAF.

Parts.	*Qualities.*
The upper face.	It is oval.
under face.	smooth.
edge or margin.	pointed.
point or termination.	vegetable.
veins.	odorous.
middle rib.	opaque.
base.	bitter.
stalk.	stiff.
	long.
	The rib is straight.
	raised, or keeled on the under side.
	grooved on the upper side.
	The veins are curved.
	The margin is curved.
	slightly toothed.
	The upper face is bright.
	The under face is dull.

LESSON XX.

A NEEDLE.

Parts.	*Qualities.*
The eye.	It is a mineral.
shank.	metallic.
point.	artificial.
middle.	opaque.
top.	bright.
	cold.
	taper.
	pointed.
	slender.
	useful.
	fusible.
	grey or steel colour.
	hard.
	brittle.
	solid.
	steel.

Made of steel, which is a preparation of iron, having been subjected to great extremes of heat and cold.

LESSON XXI.

A STONE.

Idea to be developed by this lesson,—*inorganized.*

To give the class an idea of *organized* and *inorganized*, a plant might be shown with the stone; and questions given, such as the following.

TEACHER. If I put these two into the earth, and visit them in a month, what great difference might I expect to perceive in them?

CHILDREN. The plant will have grown; the stone will have remained the same size.

TEACHER. How did the plant increase?

CHILDREN. It absorbed moisture.

TEACHER. By what means?

CHILDREN. Through its roots and pores.

TEACHER. Did this nourish only the roots?

CHILDREN. No.

TEACHER. You are right; the sap was produced which circulated through the plant by means of vessels. You remember why we call the eyes, ears, &c. *organs?*

CHILDREN. They are natural instruments by which something is effected.

TEACHER. What would you therefore call the pores, vessels, &c. of vegetables?

CHILDREN. They are *organs.*

TEACHER. A body possessing organs is called *organized.* Name some organized bodies.

CHILDREN. A tree, an insect.

TEACHER. What syllable, placed before a word, expresses the absence of a quality?

CHILDREN. *In.*

TEACHER. What would you call a body which is destitute of organs?

CHILDREN. *Inorganized.*

TEACHER. Mention some inorganized substances.

CHILDREN. Earth, water.

Qualities of Stone.

It is hard.
cold.
inorganized.
opaque.
mineral.
solid.
natural.
shapeless or amorphous.

Remarks on Words.

Inorgan-*ized* is derived from Greek ὀργαν-ον (organon), an instrument.

LESSON XXII.

A BELL.

Ideas to be developed in this lesson,—*sonorous* and *the peculiar parts.*

Parts.	*Qualities.*
The barrel.	It is metallic.

The ears, cannon.	It is artificial.
handle, according to the sort.	hard.
	elastic.
	sonorous.
clapper.	cold.
rim.	hollow.
surface.	concave.
inside.	heavy.
outside.	rim circular.
	clapper spherical.

Different kinds of bells.

House-bells, pulled by wires passing from one part of a house to another part where they are rung. *Church-bells*, suspended at the upper part of the building, pulled by ropes ;—when there are several bells of different tones, they form a peal or chime ;—when one is rung slowly, it is said to be tolled. *Hand-bells.* Swung by the hand—some used in houses, some by dustmen, towncriers, postmen, &c. *Sheep-bells.* Swung round the neck of one sheep of a flock.

Uses of bells.—To give notice of different things—in the house, of different people arriving, servants wanted—in a church, the time of divine service is marked, deaths and funerals announced by tolling, marriages and happy events by a peal. The sheep-bell is used to keep the flock together; with other

animals, they are used to stimulate and encourage them in their work.*

LESSON XXIII.

A WHEEL.

Ideas to be developed in this lesson,—*circular, diverging, and the peculiar parts.*

Parts.		*Qualities.*
The nave.	The rim is	circular.†
box.		divided.
spokes.		wooden.
arm of the axle-tree.		thick
linch-pin.	The tire is	circular.
rim composed of felloes.		entire.
tire or band.		iron.
rivets.		thin.
centre.	The spokes are	straight.
circumference.		equal in length.

* This is not put down as what is to be told children, but as what their observation and conception may be exercised upon, and to suggest how the interest in lessons may be kept up.

† The children will probably say, round. They should be led to see that this is a very indefinite term, which they apply to a ball as well as to a shilling; their observation should be directed by questions to the perception of how a sphere and a circle differ, and the term circular, given and applied to the wheel before them, and to absent objects of a similar shape.

The spokes are wooden.
diverging from
the nave.

The relative position and proportion of the different parts should form a part of the exercise.

The nave is in the centre; the spokes diverge from the nave to the rim, and are all of equal length, if not, the rim would not form a perfect circle; the tire is outside the rim, and forms, of course, a larger circle than the rim which it encloses; the arm of the axle fits into the box; the felloes are parts of a circle, and are joined together, forming the rim.*

The children should also be led, as an additional exercise, to see the use and adaptation of the different parts. The box to receive the arm of the axle-tree upon which the wheels turn—the spokes to keep the rim in its circular form and to unite the nave and the rim—the tire to keep all the parts in their place and to give strength; the tire is put on when the iron is expanded by great heat, and being suddenly cooled, it contracts, and this binds the whole firmly together. The linch-pin passes through the arm of the axle-tree, and keeps it fixed in the box.

The use of wheels is, by their rotary motion to impel carriages of different kinds; the children might name the various vehicles in which they are used; they might also be led to see that no other form than that of a circle would answer for a wheel.

* These parts are mentioned in 1 Kings, vii. 33.

LESSON XXIV.

An exercise which gives a pleasing variety to lessons on objects, and which calls out thought and conception—consists in the Teacher, instead of presenting an object for examination, giving the children a description of one, and requiring them from the qualities attributed to it to discover what it is. Some judgment is necessary in giving such a lesson, that the children may be led to correct their hasty conclusions, and to see that it is not one quality which decides what a material is, but the combination of several. An example is given, to help the teacher in carrying out the idea.

TEACHER. I will tell you the qualities of something I am thinking about, and you must try and find out what it is. It is white and natural.

CHILDREN. Milk?

TEACHER. No; it is solid.

CHILDREN. Chalk?

TEACHER. No, it is vegetable and odorous.

CHILDREN. A white lily?

TEACHER. No; for it is friable and highly inflammable. Now repeat the qualities I have mentioned and think what substance possesses them all. White, natural, solid, vegetable, substance, odorous, and highly inflammable.

Children will not fail to find out that it must be Camphor, having in a former series had a lesson on the object.

It will be obvious that the qualities first mentioned are common to many substances, without sufficiently distinguishing any one. The children's conception is therefore engaged in calling up in their minds a variety of objects familiar to them. The art of the Teacher is to keep at first in the background distinguishing qualities, so as more thoroughly to stimulate the conception, and in the end to lead the children to see more clearly the peculiar and distinguishing qualities of the substance.

FOURTH SERIES.

INTRODUCTORY REMARKS.

The chief aim proposed in this series is, to exercise the children in composing, arranging, and classifying objects, and in tracing analogies; thus developing a higher faculty than that of simply observing their qualities. The complex operation of connecting things by their points of resemblance, and at the same time of distinguishing them individually by their points of dissimilarity, prepares for one of the highest exercises of our reason; yet it may be carried on in children at a much earlier period than is usually imagined, if they are trained to arrange their ideas. With this view the spices and liquids have been chosen as forming a connected series of objects. The metals, different woods, grains, &c., are good subjects for similar instruction.

In the early lessons the perceptions simply exercised the intuitive faculties, which, being stimulated and directed, furnish the mind with ideas. At this point, the process commences of regarding them, not simply, but in series and relationship, and

lessons are given to cultivate the discernment of analogies between physical and moral or spiritual qualities.*

SPICES.

LESSON I.

PEPPER.

Qualities of Pepper.

It is hard.
vegetable.
foreign.†
tropical production.
wrinkled.
spherical.
rough.
black.
conservative.
dry.

* See Home Education, p. 297.

† TEACHER. If it come from a foreign country, how do we get it?

CHILDREN. It comes in a ship.

TEACHER. This is called importing; and sending out of our own country is called exporting. What do we call this exchange of production?

CHILDREN. Trade or commerce.

TEACHER. And what are the people called who carry it on?

CHILDREN. Merchants.

It is dull.
sapid.
pungent.
odorous.
aromatic.
wholesome.
stimulating.

The pepper-plant is a creeping shrub, much resembling the vine, and is often called the pepper-vine. It is generally planted near some thorny bush, among the branches of which it entwines itself like ivy. It produces berries in clusters; if the fruit be intended for black pepper, it is not allowed to ripen, but is collected whilst green, and rubbed by the hands or feet, till the seeds, several of which are contained in each berry, are separated. These are exposed on mats to the rays of the sun during the day, and are collected at night in jars, to preserve them from the dew. When the berries are intended to be converted into white pepper, they are allowed to ripen, and they then become red. They are rubbed in a basket, the pulp is removed by washing, and the seeds, which are white, are dried.

LESSON II.

NUTMEG.

Qualities.

It is sapid.

It is hard.
oval.
dingy brown.
dull.
opaque.
dry.
vegetable.
natural.
foreign.
tropical production.
pungent.
conservative.
pulverable.
agreeable to the taste.
aromatic.
odorous.
Surface uneven.

The nutmeg is the kernel of a fruit which is the produce of a tree resembling our cherry-tree, both in size and growth. It is found in the East Indies. The external covering of the fruit is a husk: this opens when ripe, and displays a thin scarlet membrane, called mace: this being carefully removed, there still remains a woody shell which surrounds the nutmeg. The nuts are first dried in the sun, and then placed on a frame of bamboos over a slow fire, until the kernels, on being shaken, rattle in their shells.

Remarks on Words.

TEACHER. Why is nutmeg said to be odorous?

CHILDREN. Because it has a smell.

TEACHER. Why aromatic?

CHILDREN. Because it has that pungent smell distinguished by the name aromatic.

TEACHER. Are all things that are aromatic also odorous?

CHILDREN. Yes.

TEACHER. Are all things that are odorous also aromatic?

CHILDREN. No.

TEACHER. Is an onion odorous?

CHILDREN. Yes.

TEACHER. Are these smells alike?

CHILDREN. No.

TEACHER. Which of these terms includes every kind of smell?

CHILDREN. Odorous.

TEACHER. If you were to put all odorous substances into one class, and all aromatic into another, what would you say of the two classes?

CHILDREN. That the class containing all odorous objects would be much the largest; it would include the aromatic substances.

TEACHER. A term which includes all the varieties of one kind or quality of substance, is called a *generic* term, whilst that which marks one of the

species is called a *specific* term. Which is the generic term, odorous or aromatic?

CHILDREN. Odorous.

TEACHER. Why is this a generic term?

CHILDREN. Because it includes every variety of odours.

TEACHER. What kind of term is aromatic?

CHILDREN. A specific term.

TEACHER. Why?

CHILDREN. Because it applies only to one particular kind of smell.

Give examples of generic terms and of a specific term applicable to each of them.

CHILDREN. Odorous, fragrant; coloured, red; foreign, Chinese production.

The class should determine, in succeeding lessons, what terms are generic and what specific.

LESSON III.

MACE.

Qualities.

It is pungent.
agreeable to the taste.
aromatic.
orange red.
dull.
opaque.

It is thin.
fibrous.
brittle.
foreign.
tropical.
natural.
inflammable.
medicinal.
dry.
pulverable.
membranaceous.
conservative.
imported.
sapid.
stimulating.

Mace is the covering between the shell of the nutmeg and its external husk.

Remarks on Words.

TEACHER. "Foreign." Should you call mace a foreign production if you were in the place where it grows?

CHILDREN. No. It is only foreign to the countries where it does not grow.

TEACHER. Where would you call it pungent and aromatic?

CHILDREN. Everywhere.

TEACHER. Can it be mace without being foreign?

CHILDREN. Yes.

TEACHER. Can it *be* mace without being pungent and aromatic ?

CHILDREN. No.

TEACHER. Which then of these qualities belong to mace as mace ?

CHILDREN. Pungent and aromatic.

Those qualities which determine anything *to be* what it is, are called *essential*, from the Latin *esse*, to be.

Qualities which are not essential are called *accidental*, from the Latin *accidens*, happening.

What qualities of mace are essential ?

What qualities of mace are accidental ?

Why are pungent and aromatic said to be essential qualities ?

Why is it, being foreign, said to be accidental ?

LESSON IV.

CINNAMON.

Qualities.

It is light brown, and gives name to a colour.
thin.
brittle.
conservative.
aromatic.
pungent.
agreeable to the taste.
opaque.

It is hard.
sweet.
inflammable.
dry.
vegetable.
natural.
foreign.
light.
pulverable.
medicinal.
stimulating.
flaky.

Cinnamon is in the inner bark of the branches of a kind of laurel-tree, growing in Ceylon and Malabar. The branches of three years old are selected as furnishing the best cinnamon: the outside bark is scraped off; the branches are then ripped up lengthways with a knife, and the inner bark is gradually loosened, till it can be entirely taken off. Exposure to the sun causes it to curl up. The pieces of bark so curled are called quills, and the smaller ones are inserted into the larger.

Remarks on Words.

Inflam-*mable*, is derived from Flam-*ma*, a flame.
Medicin-*al*, ... Medicine.

LESSON V.

GINGER.

Qualities.

It is fibrous.
knotty.
sapid.
rough.
jagged.
vegetable.
tropical.
foreign.
aromatic.
pungent.
dry.
dull.
solid.
hard.
conservative.
light.
yellowish brown.
pulverable.
medicinal.
stimulating.
wholesome.
opaque.
inflammable.

Ginger is the root of a plant resembling a reed, which grows both in the East and West Indies. The root does not strike to a considerable depth in the earth, but spreads wide. When first dug up, it is soft, and eaten by the Indians as a salad. If intended for exportation, it is placed in bundles, and dried in the sun.

LESSON VI.

ALLSPICE.

Parts.	*Qualities.*
The inside.	It is aromatic
outside.	odorous.
skin.	pungent.
seeds.	spherical.
partition of seed-vessel.	brown.
point of insertion.	speckled.
	organized.
	natural.
	vegetable.
	dry.
	opaque.
	tropical.
	imported.
	dull.
	stimulating.
	hard.
	inflammable.

It is friable.
sapid.
wrinkled.
conservative.

Allspice or Pimento is the dried berry of a species of myrtle, indigenous in the West Indies; it is a most beautiful and fragrant tree, producing numerous bunches of white flowers, to which succeed the berries; these are gathered by the hand and spread out in the sun to dry. In this operation they lose their former colour, and become brown. When the seeds rattle in the shell, they are known to be sufficiently dry, and are packed in bags for exportation. The flavour of pimento is considered to unite that of the other spices; hence the name of Allspice.

LESSON VII.

A CLOVE.

Parts.	*Qualities.*
The calyx or cup.	It is aromatic.
tube.	odorous.
leafits of cup.	pungent.
points of leafits.	brown.
bud.	organized.
edges.	natural.
	vegetable.
	dry.

It is opaque.
tropical.
imported.
dull.
stimulating.
hard.
inflammable.
conservative.

The bud is spherical.
The tube is long.
The leafits are pointed.

Cloves are the unexpanded flower-buds and calyx of a species of laurel which grows in the West Indies. At a certain season of the year, the clove-tree produces a profusion of flowers in clusters; they are gathered before the flower opens, when the four points of the calyx project, and the petals are folded one over the other, forming a bud about the size of a pea. After they are gathered, they are exposed for some time to the smoke of a wood fire, and then to the rays of the sun.

At the conclusion of the lesson on Spices, the children should be called upon to mention those qualities which they had found common to all; as aromatic, pungent, dry, tropical, stimulating, vegetable. Then let some other similar substance be presented to them, such as mustard.

TEACHER. Is this a spice?

CHILDREN. No.

TEACHER. Why not?

CHILDREN. It has not the qualities of a spice.

TEACHER. If I showed you a substance with which you were not previously acquainted, and you found that it possessed the *essential* qualities of the spices you have examined, what would you consider it to be?

CHILDREN. A spice.

TEACHER. To what then do you apply the term spice?

CHILDREN. To a set of natural productions possessing certain qualities.

TEACHER. When a number of things are arranged together, each having similar qualities, what would you call the collection? What would you call a number of boys who are placed together because they are nearly equal in knowledge?

CHILDREN. A class.

TEACHER. What, then, would you call a collection of substances that possess the same qualities?

CHILDREN. A class.

TEACHER. What may you call all substances which are aromatic, pungent, tropical, &c.?

CHILDREN. *A class.*

TEACHER. And what is the name of that class?

CHILDREN. *Spice.*

TEACHER. What, then, does the term spice express?

CHILDREN. A class of substances, possessing the qualities aromatic, pungent, &c.

TEACHER. Tell me all the substances belonging to that class.

CHILDREN. Pepper, nutmeg, mace, cinnamon, ginger, allspice, cloves.

TEACHER. Are all the substances of this class alike in all respects?

CHILDREN. No.

TEACHER. How can you tell one spice from another?

CHILDREN. By each having some qualities peculiar to itself.

TEACHER. Name something in each spice which distinguishes it.

CHILDREN. Ginger is a root; pepper is a seed; nutmeg is a kernel; mace is the membranaceous covering of that kernel; cinnamon is a bark; pimento is a seed-vessel; the clove is a cup and flower-bud.

ON LIQUIDS.

LESSON VIII.

WATER.

Qualities of Water.

It is fluid.
transparent.
clear.

It is colourless.
liquid.
useful.
bright.
incompressible, except by immense power.
reflective.
drinkable.
wholesome.
tasteless.
cold.
inodorous.
natural.
solvent.
refreshing.
penetrating.
purifying.
cooling.
fertilizing.
heavy.

Some waters are medicinal.

Different kinds of Water.

Rain.
spring.
sea, or salt.
river.
medicinal.
hot spring.
stagnant.

Different states of Water.

Ice.
snow.
hail.
rain.
mist.
fog.
cloud.
vapour.
dew.
steam.

Natural Collections of Water.

Oceans.
seas.
rivers.
lakes.
ponds.
springs.

Operations of Water.—It purifies, evaporates, freezes, quenches thirst, cools, finds its own level, penetrates, fertilizes, is a solvent, extinguishes fire, separates easily into portions which assume a spherical form.

Movement of Water.

TEACHER. In what way do oceans and seas move?

CHILDREN. In waves.

TEACHER. When you are on the sea-shore, what difference do you observe in the waves during the course of the day?

CHILDREN. At one time they are coming in; at another going out.

TEACHER. This is called the ebb and flow of the tide. What is the movement of a river?

CHILDREN. It flows.

TEACHER. What eventually becomes of its waters?

CHILDREN. They are lost in some ocean or sea.

TEACHER. What is that which with us is always flowing on?

CHILDREN. Our life.

TEACHER. To what does it conduct us?

CHILDREN. To eternity.

TEACHER. Of what, then, is a river a fit emblem, or representation?

CHILDREN. Of life.

TEACHER. Find some passages in the Bible where a river is used as an emblem of life.

TEACHER. You find the particles of water run about; will the particles of wood do the same?

CHILDREN. No.

TEACHER. Why will not the particles of wood flow about?

CHILDREN. Because they stick close together.

TEACHER. This is called *cohering*. You remember what adhesive is derived from.

CHILDREN. From ad, *to*, and hær-*ere*, to stick.

TEACHER. Cohere is derived from cohær-*ere*, to stick together. When one substance is joined to another it is said to adhere (or stick to): when the

particles of the same substance stick together, they are said to *cohere*.

The particles of a liquid cohere very slightly, and are therefore easily separated. The particles of a solid cohere closely.

LESSON IX.

OIL.

Qualities of Oil.

It is fluid.
yellowish.
semi-transparent.
soft.
liquid.
penetrating.
emollient.
greasy.
light.
thick.
inflammable.
oleaginous.
Some oils are vegetable.
Some are animal.
When bad, it is rancid.
odorous.

The vegetable oil is expressed from olives, and is imported chiefly from Italy and the south of France.

It is also obtained from nuts and some other fruits, and from seeds.

The animal oil is procured from the blubber or fat of the whale and seal.

Birds are furnished with little bags containing oil; with this they plume their feathers, and it causes rain and moisture to trickle off. Without this provision, the feathers of water-fowl would imbibe so much moisture, that they would become too heavy to float on the water.

LESSON X.

BEER.

Qualities.

It is liquid.
fluid.
orange-colour.
wholesome.
fermented.
artificial.
odorous.
semi-transparent.
slightly-intoxicating.
strengthening.

Beer is composed of malt, hops, and water, boiled together. Hops are the blossoms of a creeping plant, very much cultivated in Kent: the place where they grow is called a *hop-yard*. The tub in which

the malt is first steeped is called a *mashing-tub:* that which holds the beer when made, a *vat:* when wanted for consumption, or sale, it is put into *barrels.*

Malt is made of barley, by the following process. A quantity of barley is soaked in water for two or three days ; the water being afterwards drained off, the grain heats spontaneously, swells, bursts, becomes sweet, and ferments. Vegetables, during decomposition, undergo several degrees of fermentation ; the first (that above described) is called the *saccharine fermentation*, from the sweetness it produces ; sacchar-*um*, being the Latin for sugar. In consequence of this decomposition, which is similar to that which takes place in seed in the ground, the barley begins to sprout, but this vegetation is stopped by putting it into a kiln, where it is well dried by a gentle heat.

LESSON XI.

FOREIGN WHITE WINE.

Qualities.

It is yellowish.
bright.
fluid.
liquid.
fermented.
spirituous.
intoxicating.
heating.

It is vegetable.
artificial.
semi-transparent.
sapid.
medicinal.
stimulating.
clear.
strengthening.
yielding to the touch.

Wine is made from the grape, the fruit of the vine, which is cultivated in *vineyards*. The season of its gathering is called *the vintage*. The grapes, when gathered, are placed in a *wine-press*, by which the juice is expressed; this juice undergoes a fermentation, and becomes wine. This is the second fermentation which vegetable matter undergoes: it is called the *vinous fermentation*, from its producing wine; *vinum* being the Latin word for wine.

LESSON XII.

VINEGAR.

Qualities.

It is acid.
orange-brown colour.
liquid.
fluid.
yielding to the touch.

It is penetrating.
stimulating.
vegetable.
artificial.
medicinal.
odorous.
conservative.
semi-transparent.
fermented.

Uses.—To flavour food; for pickling; for medicine.

It is called Vinegar, from the French *Vinaigre*, *Vin*, wine,—*aigre*, sour; because it is frequently procured from wine. The fermentation by which this acidity is produced is called the *acetous fermentation*, from Lat. *acetum*, vinegar.

LESSON XIII.

INK.

Qualities.

It is black.
bright.
useful.
opaque.
artificial.
liquid.
astringent

It is fluid.
yielding to the touch.
poisonous.

Ink is made of galls, sulphate of iron, gum, and water. Galls are found upon the oak; they are occasioned by a little insect, which pierces the bark of the tree, and lays its eggs in the hole which it has formed. The torn vessels of the tree discharge a portion of their contents, this hardening, forms at first a defence for the eggs, and subsequently food for the caterpillars they produce; these latter eat their way out of their confinement, before they change into the perfect insect. Iron dissolved in sulphuric acid, is called *sulphate of iron;* when this is applied to the acid of the galls it becomes black, upon which quality the utility of ink depends. A little gum is added, to cause the ink to adhere to the paper.

LESSON XIV.

MILK.

Qualities.

It is white.
fluid.
liquid.
wholesome.
sweet.
nice.
An animal substance.

It is natural.
opaque.
soft.
smooth.
yielding to the touch.
emollient.
nutritious.
When fresh, it is warm.

Uses.—For animals to feed their young; for making cheese and butter; to drink.

The milk of cows is that most generally used by man. Invalids drink the milk of asses. In Tartary the milk of mares is used; in Switzerland that of goats; in the northern countries that of reindeer; in Arabia that of camels.

The teacher would find it a very improving and interesting exercise, to take two substances and compare them together,—as water and milk, requiring the class to find out in what respects they are both alike. They are both fluid, liquid, cool, incompressible, penetrating, natural, &c. The qualities by which they are distinguished from each other should then be mentioned. The water is transparent, the milk is opaque; the water is colourless, the milk is white; the water is tasteless, the milk is sweet, &c.

Liquids possess qualities by which they are very clearly distinguished from other substances. They

may all become solid, they are all fluid and incompressible; their parts easily separate, forming into spheres or drops; they penetrate into the pores of substances; and they find their own level. The last circumstance can easily be proved to the pupils by means of a syphon. Having named the properties *common* to *all* liquids, the class should also be required to mention the qualities *peculiar to each*, as in the lessons on spices.

Water is transparent, colourless, tasteless, inodorous, bright.

Oil is yellowish, thick, emollient, semi-transparent, greasy, inflammable.

Beer is orange-coloured, bitter, spirituous, artificial, fermented.

White wine is bright, yellowish, intoxicating, stimulating, fermented.

Vinegar is acid, orange-coloured, semi-transparent, fermented.

Ink is black, bright, opaque, artificial.

Milk is white, opaque, sweet, nourishing, natural.

The children might determine which of these would form a particular class within the general class of liquids; as beer, wine, vinegar, united together, because they are fermented liquids.

LESSON XV.

FIRE.

Qualities.

It is bright.
reddish yellow.
spreading.
consuming.
drying.
purifying.
hot.
Flames are pointed.
ascending.

How produced and fed.—Fire can be produced by friction; rubbing two pieces of wood or stone briskly together; the collision of flint and steel occasions sparks that will set fire to any inflammable material; but lucifer-matches, which are tipped with a very combustible substance, are now generally used to produce fire. The fuel that feeds fire is either coal, wood, or peat.

Effects of fire.—Some substances, as coal, wood, &c., it consumes, reducing them to ashes. Some, as butter, metals, &c., it melts or changes from solids to liquids. Some, as water, quicksilver, &c., it changes into steam, or vapour. Some substances, as dough, clay, &c., it hardens. It expands bodies, penetrating through their particles and loosening

them. Some substances, as metals, it refines, driving away impurities.

Uses.—1. In domestic life. It warms our houses and gives light to us when the natural light of day is removed. It cooks our food, thus enabling us to profit by the animals and vegetables which God has given us.

2. In manufactures. By fire, metals are fitted for various purposes. Glass, porcelain, brick-making, indeed all our manufactures, require the aid of fire. It is also fire that furnishes us with the steam that enables us to travel with such rapidity by sea and land, and which lights our streets and houses at night.

*An emblem.**—There are many instances in the Bible of Fire being used as an emblem. Thus God is spoken of as a "consuming fire." His wrath, when kindled by sin, destroys like fire. Our Saviour is compared to the refiner's fire, purifying his people, purging them from the dross of sin, as fire acts upon metals.

LESSON XVI.

AN ANCHOR.

Parts.	*Qualities.*
The shank.	It is iron.

* An emblem is a picture which represents one thing to the eye and another to the understanding.

The cross-bar or stock. It is heavy.
arms. hard.
flukes. cold.
ring. opaque.
metallic.
The shank is perpendicular to the beam.
The beam is straight.
horizontal to the shank.
smaller at the ends.
sometimes iron.
sometimes wooden.
The arms are curved.
The flukes are pointed.
sharp.
The ring is circular.

The largest kind of anchor is called the *sheet anchor*, and is only used in times of great danger or in heavy gales.

The anchor is an instrument of iron attached by a cable, which passes through the ring to the bows of ships; when the latter are to remain stationary, the anchor is let down or cast into the water, and is thrown by the stock into such a position that one of the flukes is sure to enter the ground perpendicularly: this keeps the vessel fixed, for any strain acting nearly horizontally would rather tend to root the arm deeper in its moorings. This operation is

called *casting anchor*, and the ship is then said to be *riding at anchor;* when the anchor is heaved up, the expression used is *weighing anchor.* When the anchor finds good moorings and takes firm hold, the vessel is in safety; it cannot be driven to and fro by the storm, or dashed against rocks by the hurricane.

When the children clearly understand what an anchor is, and the office it performs, they should be led to trace the analogy between hope and an anchor. The former is thrown out from us, and is fixed upon something, and if it has a firm grasp it will keep us steady; we shall remain unshaken, whatever may assail, as long as the anchor of hope retains its hold. The children should be referred to Heb. vi., where the anchor is used as the emblem of hope, which is described as having entered into that within the veil, that is, into the Holy of Holies, the type of Heaven, where our great High Priest is for us entered; anchored on Him, the rock of our salvation, we shall be kept immoveably fixed amidst all the trials and temptations of life. We often speak of a person or thing being our sheet anchor, which means that on which we altogether depend as our last and best resource.

LESSON XVII.

A BALANCE.

Parts.

The lever, or beam.
pivot, or fulcrum.
scales.
chains connecting the scales with the beam.

The qualities depend upon the kind of balance used in the lesson.

The balance is an instrument used to ascertain the exact weight of anything. It is most essential in trade; without such a help barter and exchange would be guess-work, and dishonest dealings could not be easily detected. When one scale perfectly balances the other, what is held in each is equal in weight, and if in one scale standard weights are placed the substance in the other can be accurately determined.

The children should endeavour to find out why the balance is employed as the emblem of justice, and why, whenever Justice is represented as a person, she always holds a pair of scales in her hand. They will be able to trace the analogy between testing a substance as to its weight in scales and the exercise of justice, which consists in impartially weighing conduct or opinions against a lawful standard, in order

to arrive at a just and right judgment. They will also understand the metaphor used to set forth the conduct of Belshazzar,—"Thou art weighed in the balance, and art found wanting." His life and character were in one scale, God's holy law and requirements in the other, and the former fell short—was altogether deficient.

At this step some exercises would be well introduced on the connexion of different qualities. The children will easily be led to discover that all absorbent objects are porous, that all brittle substances are hard, that all adhesive ones are tenacious, all sonorous ones are elastic; that to be malleable and ductile they must be tenacious, their particles cohering; to be elastic, an object must be either extensible, flexible, or compressible.

Children may also with profit exercise their conceptive powers in drawing, out of the treasures of their memory, examples of objects in which any particular quality is found, and classifying them according to the different degree in which they possess the quality. Thus objects may be remembered, furnishing a regular gradation from the most impenetrable opacity to the clearest transparency; the same may be done with hard and soft—from soft as butter to as hard as flint, &c.

FIFTH SERIES.

INTRODUCTORY REMARKS.

THESE lessons are intended as a first exercise in composition. The object should be presented to the children, and they should continue, as before, to make their own observations upon it. Questions should then be addressed to them, calculated to elicit their knowledge of its natural history, manufacture, or composition; and further particulars should afterwards be communicated by the teacher, to render their information more complete. After having rearranged and repeated the matter so obtained, the teacher should examine the class, and require a written account. Children from eight to ten years of age have derived great improvement from this exercise in composition. It stimulates their attention, furnishes a test of their having well understood the lesson, and leads them to arrange and express their ideas with clearness and facility. Artificial substances should be exhibited, both in their raw and manufactured state. Thus, in the lesson on flax, the plant itself, the fibres when separated from the stem, the thread when spun, and the various articles into which

it is manufactured, may be brought before the class, and likewise pictures of the machinery employed in the manufacture.

Many of the lessons in the following series will contain too much matter to be presented at one time to the pupils, and must therefore be divided.

LESSON I.

CAMPHOR.

Camphor is the peculiar juice of a species of laurel called the camphor-tree, which is abundant in China, Borneo, and Ceylon. Exposure to the air hardens it. It is remarkably inflammable, and is used by the Indian princes to illuminate their rooms. It is pungent, volatile, acrid, and strongly aromatic. These qualities have rendered it useful as a stimulating and restorative medicine, and in sick rooms to prevent contagion. It is also placed in cabinets of natural history, to destroy the small insects which prey upon the specimens.

LESSON II.

WAX CANDLE.

Wax is the produce of bees: it is a substance which is secreted in their bodies, and of which they construct their cells. When the honey is taken out

of the comb, the latter is melted, and afterwards bleached by exposure to the air. The wax in a liquid state is poured into leaden moulds, in the centre of which the wick has been previously fixed. The wick is made of cotton or flax, and when lighted, the melted wax rises up its fibres and feeds the flame.

LESSON III.

PUTTY.

Putty is a soft unctuous substance, which hardens by exposure to the air, and is used by glaziers to fasten the panes of glass to window-frames. It is composed of linseed oil and whiting, sometimes with the addition of white lead. The whiting is prepared from chalk ground into a fine powder; and the oil and white lead are worked into it, till all the substances are thoroughly mixed together. Linseed oil is extracted from the seed of the flax; it is so called from linum, the botanical name of the plant.

Shell lac

LESSON IV.

SHELL LAC.

Shell lac is a substance produced by a little insect called Coccus Lacca, and is deposited on the small branches of the Indian fig-tree, for the protection of its eggs. It discharges the gum from its own body, and forms it into cells, in each of which is placed an

egg. When the eggs are hatched the young grub pierces through the viscid substance which enclosed it, and flies away; and the material provided for a little insect's well-being becomes a valuable article of commerce.* The lac is first sold on the sticks, when it is called *stick lac;* but after it has been purified and formed into thin layers or cakes, it is called *shell lac.* It is the principal ingredient in sealing-wax and varnish, and is employed in japanning. Its usefulness arises from its being fusible, soluble, and adhesive.

LESSON V.

BUTTER.

Butter is prepared from the milk of the cow. When milk has been allowed to stand a few hours, a thick, rich substance, called *cream*, rises to the surface. This is skimmed off, and by being briskly agitated, is converted into butter. The instrument by which this operation is performed is called a *churn.* There is another substance found in the churn besides butter: it is called *butter-milk*, and when fresh is drunk by the peasantry. The butter prepared for

* The children would be interested in recollecting many instances of this primary and secondary use of substances, and their attention might be directed to a perception of the difference between man's work and that of the lower creatures; the latter led by instinct, the former by reason and experience, resulting in discovery.

winter store is salted, and packed in barrels and tubs. The person who attends the cattle is called a *cowherd;* and the place where the milk is kept, a *dairy.*

LESSON VI.

CHEESE.

Cheese is prepared from milk which is coagulated or curdled, by mixing it with a liquor called rennet: the curds thus formed are a white solid substance; they are separated from the *whey* or watery particles of the milk, and then pressed and dried. Rennet is made by steeping the inner membrane of a young calf's stomach in water. A colour is usually given to cheese by saffron, or by a substance called *annato,* which is the seed-vessel of a shrub growing in the West Indies.

LESSON VII.

HORN.

Horn is the hard substance that forms the frontal projections of horned animals, all of which are graminivorous or grass eaters.* This substance, when boiled, becomes a soft jelly, and can be moulded into any shape. By a peculiar process it is rendered semi-transparent, and when formed into thin laminæ or plates is employed instead of glass for lanterns.

* From Latin, gram-*en,* grass; vor-*are,* to eat

It was the first transparent substance used for windows. It is now chiefly employed for combs, handles to knives and forks, occasionally for drinking utensils and inkhorns. It was formerly in much greater request than it is now, glass having been substituted in its place.

LESSON VIII.

HONEY.

Honey is a sweet vegetable juice, collected by bees from the nectaries of flowers. These insects are furnished with a long hollow trunk or proboscis, which they insert into the tubes of flowers and suck up the honey they contain; when well-laden with their treasure, they carry it home and deposit it in their cells for a winter store.

The description given of Judæa as a "land flowing with milk and honey," was literally true. The richness of the vegetation supplied the bees with ample stores; their combs were usually placed in clefts of rocks or the hollows of trees, and being continually melted by the heat of the sun, the honey actually flowed out of them in streams. See 1 Sam. xiv. 25, 26.

LESSON IX.

STARCH.

Starch is a white substance, with scarcely any smell

or taste; it is insoluble in cold water, but combines with warm water, forming a kind of jelly. It may be obtained from several farinaceous vegetables, but is generally prepared from wheat, by the following process. The wheat is put into tubs of water, and exposed for some days to the heat of the sun, which brings on a degree of fermentation; during the process the water is changed twice a-day. When sufficiently softened, it is poured into large canvas bags, which are worked or beaten, in order to separate the husks from the farinaceous particles; these last are received into an empty vessel. Fresh water is then mixed with them, and the whole is left to settle; the water is poured off, and the sediment which remains at the bottom of the vessel is *starch:* this is formed into small pieces and dried. Starch, with the addition of smalt or stone blue, is used to stiffen linen: it is also formed into a powder for the hair. Starch, or Fecula, is the nutritive part of most grains and roots; it may be extracted in considerable quantities from potatoes.

LESSON X.

SAFFRON.

Saffron is the orange-coloured pistil of a purple species of crocus, the leaves of which appear in spring, and the blossoms in autumn. It abounds in the neighbourhood of Saffron Waldon, in Essex,

which takes its name from that circumstance. The flowers are gathered every morning just before they expand: and as they continue to open in succession for several weeks, the saffron harvest lasts a considerable time. When the flowers are gathered they are spread on a table: the upper part of the pistil only is of any value. When a sufficient quantity of these are collected, they are dried upon a kind of portable kiln; over this a hair cloth is stretched, and upon it a few sheets of white paper; the saffron is placed upon these to the thickness of two or three inches: the whole is then covered with white paper, over which is placed a coarse blanket or canvas bag, filled with straw. When the fire has heated the kiln, a board, on which is a weight, is placed upon the blanket, and presses the saffron together. Saffron has a sweet odour—a pungent, bitterish taste, and is of a deep orange red colour. It is used as a medicine, to flavour cakes, and to form a yellow dye, valuable to painters and dyers, and to colour cheese and butter.

LESSON XI.

COURT-PLASTER.

Court-plaster is a black, adhesive, thin substance, applied to wounds on the skin, to protect them from the injurious effects of the air. The following is the manner of preparing it: a thin black sarcenet is stretched on a frame; a warm solution of isinglass

is applied with a brush equally over the surface; when dry, this operation is repeated a second or third time. It is next washed over with some benzoin dissolved in spirits of wine. Benzoin is a resinous gum, which exudes from a tree growing in Sumatra, and possesses an aromatic perfume, and acts as a styptic. It is the chief ingredient in Friar's Balsam, and gives it the healing virtue it possesses.

LESSON XII.

GLUE.

Glue is a viscid, tenacious substance, used as cement. The best is obtained from the skin of animals, generally the shavings, parings, and strips, which have been rejected by the currier. An inferior kind is procured from the hoofs, sinews, &c., of animals. It is prepared by steeping the skin for two or three days in water, then boiling it till it becomes a thick jelly; whilst hot it is strained through osier baskets, the pure glue passes through the interstices, leaving the impurities in the basket. It is then melted a second time, poured into square frames or moulds, and placed in the air to cool gradually and congeal. Glue is used by carpenters, joiners, hatters, bookbinders, &c.

Isinglass is the finest kind of glue, prepared from the air-bladders or sounds of all the species of the sturgeon; when fine it is of a white colour, semi-

transparent, and dry. It is used for culinary purposes, and for refining wine, also for stiffening silks, and in sticking-plaster.

LESSON XIII.

TAMARINDS.

The fruit of the Tamarind, a tree growing in the East and West Indies, is a roundish, somewhat compressed pod, about four or five inches long, the external part of which is very brittle. Each pod contains three or four hard seeds enclosed in tough skins, surrounded by a dark-coloured acid pulp, and connected together by numerous tough woody fibres. Before the tamarinds are exported the pulp, with the seeds and fibres, are taken out of the pod, and those which are the produce of the West Indies are preserved in a syrup. The East Indian tamarinds are usually sent without any such admixture. In hot countries the tamarind is valued as a refreshing fruit; and, steeped in water, it forms a cooling beverage.

LESSON XIV.

INDIAN-RUBBER, OR GUM ELASTIC.

Indian-rubber is the hardened juice of a tree which grows in South America. The Indians make incisions through the bark of the tree, chiefly in wet

weather; a milky juice oozes out, which is spread over moulds of clay: when the first layer is dry, a second is put over it; this operation is repeated till the Indian-rubber is of the thickness required. After this it is placed over the smoke of burning vegetables, which hardens and darkens it. The natives apply it to various purposes; for water-proof boots, for bottles, and also for flambeaux, which give a very brilliant light, and burn for a great length of time. The principal uses to which Indian-rubber is applied here, are the effacing of black-lead marks, for water-proof shoes, for balls, flexible tubes, syringes, and other instruments used by surgeons and chemists. Cloth of all kinds may be made impenetrable to water, if impregnated with the fresh juice of the Indian-rubber tree. Ships' bottoms are sometimes sheathed with Indian-rubber, cut very thin; it is said to be an effectual preservative from the injuries of shell-fish.

LESSON XV.

FOREIGN CURRANTS.

The foreign, or dried currants, are a species of small raisins or grapes, which chiefly grow in the Grecian Islands. They were formerly very abundant in the Isthmus of Corinth—and were called from thence Corinthians; this term has been corrupted into currants, probably from their resemblance to the

English fruit of that name. These little grapes have no stones, and are of a reddish black colour; they are extremely delicious when fresh gathered. The harvest commences in August; and as soon as the grapes are gathered, they are spread to dry on a floor, prepared for the purpose by stamping the earth quite hard. This floor is formed with a gentle rising in the middle, that the rain, in case any should fall, may flow off and not injure the fruit. When sufficiently dry, the currants are cleaned, and laid up in magazines, where they are so closely pressed together, that when a supply is needed it is dug out with an iron instrument.

They are packed in large casks for exportation, and trodden down by the natives.

LESSON XVI.

CORK.

Cork is the thick and spongy bark of a kind of oak, growing chiefly in the mountainous districts of Spain. When it is to be removed from the tree, a longitudinal slit is cut, at the extremities of which incisions are made round the trunk; it can then be stripped off with great ease by means of a curved knife with a handle at both ends. When the bark is taken from the tree, it is piled up in a ditch or pond, and heavy stones are placed upon it, in order to flatten it. After being dried, it is slightly burnt

or charred, and then packed for exportation. Cork is light, porous, readily compressible, and extremely elastic: notwithstanding its great porosity, it is nearly impervious to any common liquor. These qualities make it superior to any other substance for stoppers for bottles. Before being made into stoppers, the cork is charred,—this makes it contract, and fits it better by lessening its porosity for cutting off communication between the external air and the liquid. A piece rather larger than the neck of the bottle is inserted, the tendency it has to resume its former shape causes it completely to fill up the aperture, and exclude the air. Its buoyant effect in water, arising from its lightness, renders it useful to those who are learning to swim: for the same reason it is employed in the construction of life-boats, and for the floats of fishing-nets. The Spaniards make lamp-black of it. The men employed in cutting and preparing it for sale are called cork-cutters.

LESSON XVII.

LEATHER.

Leather is the prepared skin of various animals: that of cows, oxen, and horses, is chiefly used for shoes: that of kids, goats, and dogs, for gloves, and also shoes; and that of calves, for book-binding, saddles, harness, &c.

The unprepared skin is called a *hide;* the first

operation it undergoes is soaking in lime-water, to cleanse it from grease and other impurities; the hairs are then removed by a kind of knife, the oil and grease are afterwards more completely extracted by an alkali, or diluted sulphuric acid. After this it is taken to the tan-yard, stretched over a pit, and covered with tan; in this state it remains about two months. But if the leather be intended for the upper part of shoes, seats of saddles, and such purposes as do not require great strength or impermeability to water, it is first sent to the currier; his work is to scrape it, reducing it all to an equal degree of thickness, and also to render it supple by oil or grease. The skins are then tanned. Tan is the bark of the oak, and possesses a remarkable degree of astringency; it consequently contracts the pores of the leather, and renders it impervious to wet. The quality which the leather thus obtains from the tanning, combined with its durability and suppleness, particularly adapt it for shoes, boots, &c.

LESSON XVIII.

SPONGE.

Sponge is a marine substance, soft, porous, light, and compressible; it was formerly supposed to be a vegetable, but the opinion now generally entertained is, that it is a habitation constructed by a little worm, one of the species considered to occupy the

lowest rank in the animal kingdom. It is found firmly adhering to various marine substances at the bottom of the sea, especially in the Mediterranean, and is procured by divers, who are early trained to this employment. Sponge absorbs fluids rapidly, and yields them again when compressed. It was formerly saturated with myrrh and wine, and given to persons suffering the punishment of crucifixion, in order to deaden the sense of pain, and subdue the intolerable thirst which is the consequence of their agony. To this custom the sacred historian refers in the account of our Lord's death; but his unrelenting persecutors, instead of offering him the myrrh and wine, "filled a sponge with vinegar, and put it upon hyssop, and put it to his mouth." The offer of vinegar was considered among the Jews as an intolerable outrage to their feelings, and this is alluded to in the following passage, which at the same time foretold the future sufferings of the Redeemer of mankind,—"Reproach hath broken my heart, and I am full of heaviness; and I looked for some to take pity, but there was none; and for comforters, but I found none. They gave me also gall for my meat, and in my thirst they gave me *vinegar* to drink." (Ps. lxix. 20, 21.)

LESSON XIX.

COFFEE.

Coffee is the seed of a plant growing principally

in Arabia and the West Indies; the flower resembles jessamine, and the leaves are evergreen; the fruit when ripe is like the cherry: it contains two cells, and each cell has a single hemispherical seed. When ripe, it is either gathered by the hand, or shaken from the trees, and placed on mats for the sun to dry the pulpy substance which surrounds the seed. The husk is broken by heavy rollers, and afterwards removed by winnowing. In order to prepare the coffee for a beverage, it must be roasted till it becomes of a dark brown colour, and extremely odorous; after which it is ground, and either infused or boiled in water. It is remarkable for its very stimulating property. Its discovery is said to have been occasioned by the following circumstance. Some goats, who browsed upon this plant, were observed by the goat-herd to be exceedingly wakeful, and often to caper about in the night; the prior of a neighbouring monastery, wishing to keep his monks awake at their matins, tried if the coffee would produce the same effect upon them as it was observed to do upon the goats: the success of his experiment led to the appreciation of its value.

LESSON XX.

TEA.

The beverage called Tea is an infusion of leaves; the plant which produces them is a native of Japan

and China; it bears a flower resembling the wild rose, and the leaves are narrow, pointed, and serrated. It grows only in a stony soil, and at the foot of mountains and rocks, exposed to a southern aspect. There is great art exercised in gathering and drying the leaves, which are afterwards subjected to the vapour of boiling water to moisten them. In this state they are laid upon plates of metal, and being exposed to considerable heat, curl up. Green tea is the produce of the same plant as black; the difference of its qualities arises from the leaves being gathered in a different stage of its growth, and from their being dried upon plates of copper.

LESSON XXI.

RICE.

Rice is the grain of a kind of corn, and grows in in a spike similar to oats: it is very abundant in China, the East and West Indies, and America: it is also produced in the south of Europe. Switzerland draws its supplies from Piedmont. Patna rice is considered the finest of any other rice grown in the East; it is small-grained and very white. But the most esteemed rice is that produced in the marshy grounds of Carolina. It will not thrive without much moisture, and therefore comes to the greatest perfection in marshy lands. The cultivators of rice always inundate their grounds, and the higher the water

rises, the higher the plant grows, the ear always appearing above the water. It requires as much heat to mature the seed as it does moisture to nourish the plant in its growth. In India the women thresh and prepare the rice, which is a very laborious employment. The Brahmins live almost entirely upon it, their religion forbidding them the use of animal food. Rice is very light and wholesome, but it is considered to possess less of the nutritive principle than wheat; it is manufactured into vessels which resemble china or alabaster.

LESSON XXII.

SAGO.

Sago is the pith of the sago palm, a tree indigenous to Japan and the dry rocky mountains of Malabar.

It is hardly possible to imagine a plant more graceful in its foliage, or more beautiful when in fruit, than this species of palm. The foliation, which slightly resembles that of the fern, is placed on the stem in the manner of the feathers of a shuttlecock, forming a gigantic basket of the most graceful appearance; at the bottom of this is the salmon-coloured flower, resembling, both in shape and texture, the blossom of the cockscomb, but of a pale buff colour, inclining to brown. The fruit is a drupa, that is, a nut surrounded by a pulpy substance, as

a plum. The growth of this plant at first is slow; it appears for some time a shrub thickly set with prickles: as it increases in height, it loses its thorns. When the tree has reached its maturity, a whitish powder transpires through the pores of the leaves, and adheres to their extremities. On this intimation of the trees being filled with pith, the Malays cut them down near their roots, and divide them into several sections, which are split into quarters. The bark is woody, and about an inch in thickness; in the centre of the stem is a fat or gummy pith, which forms the sago. This pithy substance being scooped out, is diluted in pure water, and strained through a bag of fine cloth, which separates the glutinous from the farinaceous matter. This latter having lost part of its moisture by evaporation, is passed through sieves, by which process it becomes granulated, and being received into earthen vessels, it dries and hardens into little globules. Sago is extremely nutritious and wholesome, and forms an excellent light diet for invalids.

LESSON XXIII.

THE COCOA-NUT.

The tree which produces this fruit is a kind of palm; its trunk resembles a stately column, crowned at the summit with narrow leaves, fourteen or fifteen feet in length, and only three in breadth: amidst

these, hangs the fruit. The external rind of the cocoa-nut is thin, brown, smooth, and approaches a triangular form. This covering incloses an extremely fibrous substance, of considerable thickness, which immediately surrounds the nut; the latter has a thick and hard shell, with three holes at the base, each closed by a black membrane. The kernel is about an inch in thickness, it lines the shell and encloses a sweet refreshing liquid. The cocoa-nut tree affords the Indians food, clothing, and means of shelter. Before the kernel comes to maturity, it is soft and pulpy, may be scraped out with a spoon, and supplies the natives with an agreeable and nutritious food; when pressed in a mill, it yields an oil. By making incisions in the tree during the spring, a cool, refreshing liquor flows out, which, if allowed to stand any time, ferments, becomes spirituous, and is exceedingly intoxicating—it is called toddy. By soaking the fibrous trunk in water it is made soft, and can be manufactured into sail-cloth, or twisted into cordage of any description, which surpasses in durability that formed of hemp. The woody shells are very hard, and susceptible of a high polish; they are used for cups, ladles, and other domestic utensils. The trunk of the tree furnishes either beams or rafters for habitations, or is made into boats. The leaves platted together form an excellent thatch; they are also used for umbrellas, mats, and various other useful articles.

LESSON XXIV.

BREAD.

Bread, the principal article in the food of most civilised countries, is made of flour, yeast, and a little salt, kneaded together with water into a soft paste called dough. Flour is most frequently made of wheat. It is first threshed, either with a *flail* or a *threshing-machine;* the grain is next separated from the chaff by *winnowing;* it is then ground in a mill and converted into *flour;* the skin of the grain, when separated, is called *bran;* when left with the flour it makes the flour browner and coarser, but more nutritious. Yeast is the frothy substance which rises to the top of new beer; it penetrates the dough, disunites the particles, causes them to rise, and thus makes the bread light. It is similar in its effects to the leaven mentioned in Scripture, which is sour dough; it penetrates and changes the state of the whole mass with which it is mixed. Leaven is used to represent that evil disposition we inherit from Adam, and which pervades and corrupts our whole nature. Our Saviour calls himself the bread of life; intimating, that as bread, by its nutritious properties, supports our bodies, so He, by the influence of his Spirit, maintains the life of our souls. Bread is termed the staff of life, and is frequently used to signify food in general. A man is thus said to *earn*

his bread, or his subsistence; and we pray for our *daily bread*, or sufficient food.

Rye, oats, and barley, are sometimes made into bread.

LESSON XXV.

SUGAR.

Sugar is the produce of the sugar-cane, a plant growing principally in the East and West Indies. A field of canes in blossom presents a beautiful sight; the stem is a jointed culmus or reed, of a bright golden hue when ripe, and growing amidst long, narrow, pendent leaves. The flowers appear like a plume of white feathers, tinged with lilac. When ripe, the cane or stem is gathered and conveyed to the mill, where it is pressed between two iron cylinders: the juice is received into a trough, and from thence it is conveyed to a boiler, into which some quick lime is thrown; this uniting with the oleaginous particles and the superabundant acid, rises with them to the surface, and is skimmed off. When the sugar nearly boils, it is strained off into another boiler, where it undergoes the same process as before. This is repeated six or seven times, and finally it is received into coolers, which are shallow wooden vessels; in these the sugar forms into *grains*, separating itself from the *molasses:* when dry it is called *raw sugar*, and is barrelled for exportation. The process of con-

verting it into white or refined sugar is the business of the *sugar refiner* or *baker;* he boils it over again, with some purifying substances.

The *planter* is the cultivator of the sugar-canes. The *merchant* imports it. The *sugar-refiner* converts it into white sugar. The *grocer* retails the sugar in small quantities.

LESSON XXVI.

WHALEBONE.

Whalebone, a horny, elastic, and fibrous substance, is taken from the jaw-bone of the whale, the largest animal that now inhabits our globe. The vessels employed in the whale-fishery are called *whalers.* The fish is discovered by the water which it spouts up; when one is observed, six boats are immediately despatched from the whaler, with six rowers in each: a man accompanies them called a *harpooner*, from his being armed with a *harpoon*, a kind of forked instrument; it has affixed to it a rope, at the other end of which is a gourd; the harpoon having been darted into the whale, the gourd marks the spot where the wounded animal disappears. When the whale is struck, he dives with such velocity under the surface, that it is necessary to wet the rope which he drags over the side of the boat, to prevent its taking fire; and the fishermen loose their hold of it for a time, till the strength of the animal is in some degree

spent, or there would be danger of his sinking the boat by his extreme violence. The whale cannot remain long under water; he soon re-appears, spouting up blood, and is again attacked by the harpooners, who, after repeated efforts, despatch him. When dead, he is cut up. The fat, which is called blubber, is stowed into casks, and oil is afterwards procured from it. The bone is used as a stiffener for whips, bows, stays, &c. The whale fisheries are carried on in the Polar seas.

LESSON XXVII.

GLASS.

Glass is made of sand or flint, combined with an alkali, by exposure to intense heat, which causes these substances to unite and melt. This mixture is said to have been discovered accidentally in Syria, by some merchants who were driven by stress of weather upon its shores. They had lighted a fire upon the sands to cook their food; the fire was made of the plant called kali, which grows on the sea-shore; the sand mixed with its ashes, and became vitrified* by the heat. This, it is said, furnished the merchants with the hint that led to the making of glass, which was first regularly manufactured at Sidon in Syria. England is now much celebrated for its glass. The qualities which render the substance so valuable are,

* Derived from Lat. vitr-*um*, glass, and fi-*t*, it becomes.

that it is hard, transparent, incorrosive, not being affected by any substance but fluoric acid, and when fused it becomes so ductile and plastic, that it may be moulded into any form, which it will retain when cool. There are three sorts of furnaces used in making it; one to prepare the *frit*, a second to work the glass, and a third to *anneal* it. After having properly mixed the ashes and sand they are put into the first furnace, where they are burned or calcined for a sufficient time, and become what is called *frit*. This being boiled afterwards in pots or crucibles of pipe-clay in the second furnace, is fit for the operation of *blowing:* the *annealing* furnace is intended to cool the glass very gradually, for if it be exposed to the cold air immediately after it has been blown it will fall into a thousand pieces, as if struck by a hammer.

Before glass was invented, thin folia of mica were used for windows.

LESSON XXVIII.

PARCHMENT.

Parchment is the skin of sheep or goats, prepared in the following order. The wool or hair is stripped off the skin, which is then taken to the lime-pit; after this it is stretched as tight as a drum upon a frame, and the flesh pared off with a keen-edged instrument; a kind of white stone or chalk, reduced to a fine powder, is then spread upon the surface, and a

large pumice-stone, flat at bottom, is rubbed over it, which scours off the remainder of the flesh. The knife is once more applied to the skin, which is moistened and rubbed again with the pumice-stone, until the inner side is smooth. The outside then undergoes a similar operation. It is afterwards left to dry, and then is taken off the frame and given to the parchment-maker. He first puts it on an instrument called a *summer* (which is a calf's skin well stretched out on a frame), and scrapes it with a sharp iron tool, until one half of the thickness of the skin is pared off; the pumice-stone is next rubbed over it on both sides till it is rendered quite smooth.

Parchment was in use long before the invention of paper. Wills and other documents, intended to be preserved for any length of time, are written on it. It is also used for drums.

LESSON XXIX.

PAPER.

Linen paper was first introduced into England in the fourteenth century. It is made of linen rags, first carefully picked and sorted according to their quality; they are then reduced to a pulp by a machine which consists of a solid cylindrical piece of wood, into which are fastened plates of steel ground very sharp: this is fixed in a trough, into which the rags are put with a sufficient quantity of water. At

the bottom of the trough is a plate with steel bars, also ground sharp. The engine being turned round with considerable velocity, and the rags passing through the two sets of iron plates, are torn to pieces, and in the course of four hours are reduced to a pulp. The motion of the engine causes the water in the trough to circulate, and by that means constantly returns the stuff to the engine. The trough is fed with clear water at one end, while the dirty water is carried off at the other through a hole defended with wire grating to prevent the escape of the pulp. From this, which is called the *washing engine*, the pulp passes in a state of purity and whiteness to another engine, similarly constructed, and called the *beating engine*. The only difference between this operation and the former is, that the velocity is increased, and that it is no longer necessary to introduce fresh water, the pulp having been already cleansed from its impurities. From hence it passes into a large vat connected with boilers, and the heat they produce gives the pulp a degree of consistency: it is afterwards conveyed into smaller vessels, in each of which is a wheel called an agitator, which prevents it from sinking to the bottom. Into these vessels a workman dips a mould, a kind of sieve, the size of the paper to be made, and about an inch deep: the bottom is formed of fine brass wires, through which the superfluous water passes. The skill of the workman consists in taking up just so much pulp as is necessary to form the paper of a

proper thickness. Another workman is stationed to receive from the first the mould, out of which he turns the sheet upon a felt or woollen cloth; another woollen cloth is placed upon it, ready to receive the next sheet. Thus they proceed, placing alternately paper and felt, till they have made six quires of paper. This is then wheeled to the press, where great force is applied, and the water is squeezed from it. After this the paper is separated from the felt: one sheet is laid upon another, and it undergoes a second pressure. This operation is repeated five or six times, and the sheets are separated from one another between each application of the screw-press. They are afterwards hung up to dry in rooms where there is a fresh current of air. In this state the paper is absorbent, like blotting-paper; to fit it for writing, it is sized. Size is made of vellum* shavings boiled in water, with sulphate of zinc and alum finely pounded. After the paper is sized, it is again pressed four or five times, and hung up to dry as before. It is then *told* into quires, and sent to the *stationer*, who prepares it for sale.

The most ancient kind of paper was made from the Papyrus, a species of reed growing on the banks of the Nile, from whence our name *paper*. Leaves also were employed at a very early period for the purpose of preserving and transmitting the opinions and experiences of mankind; hence originated the word *folio*, (folium being the Latin for leaf), and also

* Vellum is the prepared skin of young calves.

the meaning of leaf as applied to a book. The use of bark succeeded that of leaves, generally the inner bark of the lime-tree : it was called by the Romans *liber*, and they gave the name of *liber* to a book, and we have adopted the term *library* for a collection of books. For the convenience of carrying this substance was rolled up, and in this form was denominated *volumen*, from which is clearly derived our *volume*. Our Saxon ancestors employed the bark of the beech, and called it *boc*, a name which we have transferred to our *book*. It is probable that skins of animals were the first substances upon which characters were written.

LESSON XXX.

WOOL.

The clothing manufactured from wool is particularly adapted to cold countries ; not that it communicates warmth, but, being a non-conductor of heat, it prevents that of our bodies from escaping. Wool is the hairy covering of sheep, which has a peculiar felting property ; it is taken from the living animal in the summer season, by an operation called *sheep-shearing*, and in that state is called the *fleece*. The wool of the Spanish sheep is particularly fine ; the flocks in that country are often very large, containing as many as a thousand sheep.

The first operation performed on the raw wool is

to pick and sort it ; this is particularly needful, as the same sheep produces wool of various qualities. It is next cleansed from its impurities, and committed to the *wool-comber*, who, by means of iron-spiked combs of different degrees of fineness, draws out the fibres, smooths, and straightens them. It is then prepared for the *spinner*, who forms it into threads, the more twisted of which are called *worsted*, and the less twisted *yarn*. It is then employed in the manufacture of every description of hosiery, stuffs, carpets, flannels, blankets, and cloths. England manufactures so much woollen clothing, that it was formerly considered the staple commodity of the country ; and to mark its importance the Lord Chancellor sits upon a woolsack.

LESSON XXXI.

COTTON.

The cotton plant is cultivated in the East and West Indies ; it produces a beautiful yellow flower ; and the seed-vessel is a pod containing a white downy substance which surrounds the seed. This is picked by the hand and separated from the seeds by a machine, which at the same time loosens its fibres ; afterwards it is packed in large bags, and sent by the planter to the manufacturer. It is then *carded*, that is, wound upon cylindrical cards, worked by machinery ; afterwards it is *roved*, by which process the

loose fibres are removed with an instrument resembling a comb ; it is then twisted and drawn out into threads or *yarn*, and sent to the weaver. It is made into muslins, calicoes, stockings, quilts, corduroys, &c. The machinery employed in England in carding, roving, and spinning, is quite unequalled, and occasions our cotton goods to be much sought after. In India and China some of the plants produce a buff cotton, of which nankeens are manufactured.

LESSON XXXII.

FLAX.

Flax is a slender annual plant with a hollow fibrous stem, bearing a delicate blue flower. Linen, lace, and canvas are made of its fibrous bark. When the flax is gathered it is exposed for some time to the influence of the sun, to ripen the seeds ; which are afterwards threshed out, and an oil called linseed oil* is expressed from them. The stalks are then loosely tied in bundles, fastened to poles, and placed in stagnant pools, where they are left to steep for about fifteen days. By the fermentation which ensues, the bark or flaxy substance becomes separated, when the stalks are thinly spread on the grass, in which state they exhale a very disagreeable and pernicious odour. After this operation they are beaten

* Linseed and linen are derived from lin-*um*, the Latin and botanical name of the plant.

with a mallet, which removes the pulpy substance and loosens the fibres ; the latter are then drawn through a comb with coarse iron teeth, and afterwards through one with finer teeth. The refuse is called *tow*, and is the substance used to make packing-cloths, and for the caulking of ships. The operation of *spinning*, which next succeeds, is drawing out several of the fibres and twisting them : this was formerly done by means of a *distaff*, but now it is performed in a more expeditious manner by machinery. Weaving is the final operation ; it may be regarded as a finer kind of matting. To perform it, the threads which compose the length of a piece of cloth are first disposed in order, and strained by weights to a proper tightness ; this is called the *warp*. These threads are separated by an instrument called a *reed*, into two sets, each composed of every other thread ; and while, by the working of a *treadle*, each set of threads is thrown alternately up and down, the cross-threads, called the *woof* or *weft*, are inserted between them, by means of a little instrument, sharp at both ends, called a *shuttle*, which the weaver briskly throws from one hand to the other, and which carries the thread with it. This is the most simple kind of weaving. The quality of the flax depends upon the soil in which it is cultivated ; but the fineness of the thread in some degree upon the dexterity of the spinner.

Egypt was celebrated at a very early period for the manufacture of linen ; and Ireland is so now.

LESSON XXXIII.

HEMP.

Hemp is obtained from an annual plant which thrives in a rich moist soil in temperate climates. It is much cultivated in Norfolk and Suffolk; and in Russia it forms one of the principal articles of commerce. The stalk consists chiefly of a tissue of fibres, coarser and stronger than those of flax, joined together by a soft substance, which easily rots. At the proper season it is gathered and steeped in water: then beaten in order to loosen the bark from the fibres. This is completed by an operation called *carding*, performed with an instrument resembling a comb. It is next spun, and then passes into the hands of the *rope-maker* or *weaver*, according to the use for which it is designed.

The extreme toughness, pliability, and durability of hemp, fit it peculiarly for purposes where great strength is required, as the cordage and tackle of our vessels and fishing-nets. It is computed that the sails and cordage of a first-rate man of war, require as much hemp for their construction as would be the yearly produce of four hundred and twenty-four acres of land.

Good huckaback is made from hemp, for towels and common tablecloths. Hempen cloths are generally worn by husbandmen and labouring manufacturers.

LESSON XXXIV.

SILK.

Silk is a fine glossy thread spun by a caterpillar, and constitutes the covering in which it envelopes itself when it changes from the larva state to that of the chrysalis. From the latter inanimate condition it emerges as a moth, and having laid its eggs it soon dies.

The *cocoon*, or web of the silk-worm, is an oval ball of silk, which it has spun out of a substance secreted in its own body. The shades of this silk vary from the palest straw-colour to deep yellow. In their native countries the silk-worms form their cocoons upon the mulberry-tree itself, where they shine like golden fruits amidst the leaves; but the colder climate of Europe will not allow of their being raised in the open air. They are, in consequence, kept in warm but airy rooms, and fed with mulberry leaves till they are fully grown. They change their skin several times while they are in the caterpillar state; at length they become so full of the silky matter, that it gives them a yellowish tinge; they then cease to eat. At this indication of their approaching change twigs are placed over them, upon little stages of wicker work, on which they immediately begin to form their webs. When these are finished, the downy matter on the outside, called *flos*,

is taken off, and the cocoons are thrown into warm water to dissolve the glutinous particles which had caused the silk to cohere: the ends of the threads being found, several are joined together and wound upon a reel; this is called *raw silk*. It afterwards undergoes an operation to cleanse it, and render it more supple, after which it is twisted into threads of different degrees of fineness, as required by the weaver; in this state it is called *thrown silk*. The excellence of silk as a material for dress consists in its strength, softness, lightness, lustre, and its being capable of taking the finest dyes. Silk may be made into substances varying in thickness from the finest transparent gauze to the richest velvets and brocades. Our manufacturers are supplied with silk chiefly from China, Persia, and Italy. France is the most northern climate in which silk is produced in any quantity.

LESSON XXXV.

FELT.

Felt is the substance of which hats are made. It is composed of hairs: those of the beaver are chiefly used by hatters. The operation of *felting* depends upon a peculiar construction in all hairs, which, however smooth and even they may appear, have in reality a tiled or scaly texture on the surface. The scales are so placed that they yield to the finger, if

drawn along the hair from the root to the point, but present a resistance when moved in a contrary direction. In consequence of this peculiarity, if the hair be seized in the middle between two fingers and rubbed, the root will gradually recede, and the point will approach the fingers, exhibiting a progressive motion towards the root; the imbricated surface preventing all motion in the opposite way. From this property hairs, when beaten or pressed together, begin to move in the direction of the root, and are disposed to catch hold and twist round each other, and thus to cohere and form a continuous mass, which is called *felt*. Curled hairs entwine themselves more closely into one another than those which are straight, though flexible, as these latter recede from the root in a direct line. The hatter spreads the hairs over the surface of his coarser cloth, and when pressed, the fine straight hairs, moving in the direction of their roots, form a coating; their base being inserted in the felt, while their extremities remain free. It is in consequence of this tendency to felt that woollen cloths increase in density, and contract in dimensions by being washed; and also that they do not ravel out when cut. The Zetlanders, availing themselves of this peculiar construction of hairs, felt their wool by putting it into narrow inlets of the sea, where it is exposed to the continual motion of the tides.

LESSON XXXVI.

PORCELAIN.

Clay and flint are the chief ingredients of porcelain. The first gives the plasticity and tenacity requisite for the moulding it into a shape; the latter renders it hard, and allows of a slight degree of vitrification. The following is the usual process carried on in our English manufactories of china. Flints are first calcined, then mixed in certain proportions with Cornish granite,* and ground to a very fine powder; water is poured upon this mixture, and it is twice strained through silken sieves. It is then boiled till it is of the consistency of cream, and the watery particles being evaporated, it becomes a tough paste. A portion of this substance is then placed upon a turning-wheel, and moulded by the hand with a precision and rapidity which practice only can give. Vessels of a circular shape are formed in this manner, as bowls, plates, cups, and saucers; utensils of other forms are made in moulds of gypsum, the pores of which absorbing the moisture of the clay, the vessels are contracted in size, and in consequence may be easily loosened from the mould. Each vessel thus formed is placed in a separate clay case. The furnace is filled with these, and then bricked closely up,

* It is to the large proportion of felspar in a state of decomposition that Cornish granite owes the preference which is given to it.

and they are subjected to a red heat for sixty hours. The temperature is then gradually lowered, and the porcelain is withdrawn; in this state it is called *biscuit*, and is white, dull, and porous. This process greatly diminishes the size of the vessels; and it fits them to receive the blue colour, called cobalt,* which has the appearance of a dirty grey till glazed. The *glazing* consists of lead and glass, ground to an impalpable powder, mixed in water with some other ingredients, which are kept secret. The biscuit is merely dipped into the glazing, and is then baked again for forty hours. It is now ready to receive other colours, and the gilding which the pattern may require. It is baked a third time for ten hours or more. Lastly, the gilding is burnished with bloodstone or agate, and the china is ready for the *ware-room*. The colours are changed by baking, appearing very different when first laid on to what they do when they have been subjected to heat.

ON METALS.

INTRODUCTORY REMARKS.

When these lessons on the common metals are given, it is advisable to present the specimens to the class in their several natural and artificial states,

* Cobalt is an oxide of the metal of that name.

that is, the ores and the native and manufactured metals. The plan of writing down the list of qualities has been again adopted with the metals, as the properties which form so decidedly their characteristic distinctions present a new range of ideas. The teacher should also be particularly careful to direct the attention of the children to those qualities in the metal under their consideration upon which its uses depend, leading them to trace the adaptation of qualities to certain uses.

LESSON XXXVII.

GOLD.

Qualities.

It is a perfect metal.
malleable.* 1.

* A solid piece of gold and some leaf-gold should be presented to the class, and the extreme lightness and thinness of the leaf may be felt.

TEACHER. How was the gold made so thin?

CHILDREN. It was beaten out.

TEACHER. With what do you think?

CHILDREN. With a hammer.

TEACHER. All things that can be thus extended by beating are called *malleable*, from the Latin mall-*eus*, a hammer. Could glass be thus beaten out? Could chalk? Camphor? What qualities prevent them from being malleable?

CHILDREN. Glass is brittle. Chalk is friable.

TEACHER. What qualities in gold do you think render it malleable?

CHILDREN. Its being tenacious.

It is ductile. 2.
tenacious. 3.
heavy. 4.
indestructible.
fusible.
incombustible, except by electricity.
soft, compared with other metals.
pliable.
compact.
yellow.
solid.
opaque.
brilliant.
reflective.
sonorous.

Not affected by any acid but aqua regia.*

It is considered a perfect metal, because it does not lose any of its weight when fused, nor suffer any change. Most metals become oxydated.†

When the children understand fully the different qualities, the teacher may mention to them the facts

TEACHER. What other quality in gold depends upon its being tenacious?

CHILDREN. It is ductile.

TEACHER. Ductile is derived from Latin, duc-*tilis*, capable of being drawn out.

* Aqua regia (royal water) is a mixture of muriatic acid and nitric acid.

† Substances are oxydated when they are combined with a certain portion of oxygen.

that prove the extraordinary degree in which the peculiar qualities exist in the metal.

1. Malleable. A grain of gold, the size of a pin's head, may be beaten out to cover a space of fifty square inches.

2. Ductile. A grain of gold can be drawn out to cover a wire of 352 feet in length; a guinea can be drawn out to reach nine miles and a half.

3. Tenacious. A wire one-tenth of an inch in diameter will support 500 pounds without breaking.

4. Heavy. It is nineteen times heavier than water of the same bulk.

Uses of Gold.

When alloyed with copper, gold is used as coin, and for ornamental purposes; for the latter it is fitted by its brilliancy and beauty, and also because it is not liable to tarnish.

The gold used in coinage, called standard gold, consists of a combination of about twenty-two parts of gold, and two of copper. Gold of the new standard, which is stamped at Goldsmiths' Hall, consists of only eighteen parts of gold and six copper.

Gold thread is made by covering silk or silver with gold beaten very thin.

Gilding is the art of covering the surface of a

* The combinations of metals with each other are called, in chemistry, *alloys;* but this term is commonly employed to designate those substances that lessen the value of any with which they are united.

substance with gold; this is effected by applying it either in the state of leaf, or liquid gold, to a surface covered by a cement.

Quicksilver unites with gold, communicating to it a portion of its own fluidity; it has from this circumstance been used in gilding buttons, an effect which is produced very rapidly by the following process. The metals are mixed together, and the buttons immersed in the compound. They are then exposed to great heat, by which the quicksilver is evaporated, and the gold is left upon the buttons.

The purple colour used in painting porcelain is obtained from gold.

Gold is beaten into leaves upon a smooth block of marble fitted into a wooden frame, about two feet square; on three sides there is a high ledge, and the front has a flap of leather attached to it, which the workman uses as an apron to preserve the fragments that fall off. There are three kinds of animal membrane used in the operation. For interlaying with the gold at first, the smoothest and closest vellum is procured; and when the gold becomes thin, this is exchanged for much finer skin, made of the entrails of oxen prepared for this purpose, and hence called *gold-beaters' skin:* the whole is covered with parchment, to prevent the hammer from injuring it. After the gold has been reduced to a sufficient degree of thinness, it is put between paper which has been well smoothed and rubbed with red bole, in order to prevent it adhering to the gold.

Geographical and Geological Situation of Gold.

Gold is found principally in hot climates, either native or as an ore. A metal is called *native* when it occurs in nature pure, and an *ore* when mixed with other substances. Gold is found in mines, in Brazil, Peru, and Mexico. Part of the western coast of Africa is called the Gold Coast, from the gold dust brought down by the natives to trade with. A great quantity of gold is obtained in the form of fine sand, from American and African rivers: and in small quantities from the Danube, the Rhine, and the Rhone: it is supposed to be carried down by the mountain torrents. The wandering tribes of gipsies employ themselves in washing it from the beds of the European rivers. The Himalaya mountains in Asia are rich in gold. It sometimes occurs in the veins which run through mountains, and sometimes in rounded masses in soils that are evidently the ruins of rocks. The mines which formerly yielded the largest quantities of gold were those of Peru and Lima; the principal in Europe are those of Hungary and Saltzburg. There have lately been discovered large veins of gold in California and in Australia; which will cause a great influx of this metal. The mode of extracting gold from the ore is by reducing the whole to a fine powder, and mixing it with quicksilver. The latter unites with every particle of gold, but being incapable of forming a combination with any but metallic substances, it separates the gold

from the earth with which it is intermixed. The quicksilver, which has absorbed the gold, is then evaporated by means of heat, leaving the pure metal in the vessel.

LESSON XXXVIII.

SILVER.

Qualities.

It is malleable. 1.
ductile. 2.
tenacious. 3.
heavy. 4.
indestructible.
fusible.
soft.
flexible.
a perfect metal.
opaque.
white.
solid.
compact.
natural.
brilliant.
reflective.
sweetly sonorous.
not affected by common acids.

1. Malleable. Silver can be reduced to a degree

of thinness, nearly equal to that of which gold is capable.

2. Ductile. It can also be drawn out into the finest wire.

3. Tenacious. A wire one-tenth of an inch in thickness will support 377 pounds without breaking.

4. Heavy. It is about eleven times heavier than water.

Uses of Silver.

Silver is used for coin, and is then combined with copper, to render it harder and better adapted to receive a fine and sharp impression on being cast; it does not lose its white colour by its mixture with copper. The same alloy is employed for ornamental purposes.

Silver is much used as a casing to copper utensils, to render them more pleasing to the sight, and also to prevent the formation of the poison extracted by acids from copper. The most permanent plating is effected by taking two thin plates of silver and copper, the former in the proportion of one to twelve of the latter; a little powdered borax is placed between the two metals, to promote their fusion; and then, after being exposed to a white heat, they will be found firmly united: the substance is passed between rollers till the whole is of the proper thickness for the intended manufacture.

Silver dissolved in aqua-fortis (nitric acid) yields crystals, which, being afterwards melted in crucibles,

form what is called *lunar caustic*. This preparation is of considerable value in surgical operations, being employed to burn away diseased flesh, and also for consuming warts, wens, and other excrescences of the skin. Indelible or permanent ink, used for marking linen, is made by dissolving nitrate of silver (lunar caustic) in water, and adding gum. The yellow colour employed in painting porcelain is obtained from silver.

Geographical and Geological Situation of Silver.

Silver is found, both native and as an ore, in mines and veins. America is the country richest in silver mines. It is also found in Saxony, Bohemia, Norway, Hungary, and England; but the mines of Mexico and Peru furnish annually ten times more than all those of Europe together. So poisonous are the exhalations from the mines of Peru, that many thousands of Indians have perished in them, and the cattle that graze on the outside are affected by their malignant vapours. The quantity found in England is not great; it is taken from the lead mines of Cumberland, Cornwall, and Yorkshire. A large block was found at Freyberg in Saxony, upon which Duke Albert took his dinner. When melted, it yielded 44,000 pounds of pure silver.

The ores of silver are very numerous, and various methods are employed in different countries to separate this metal from its ore. In Mexico and Peru the mineral is pounded, roasted, washed, and then mixed

with mercury in vessels filled with water, a mill being employed for the purpose of more perfectly agitating the liquid. This causes the silver to unite with the mercury, and then being submitted to heat, the latter is evaporated. The pure metal is afterwards melted and cast into bags, or ingots.

LESSON XXXIX.

QUICKSILVER OR MERCURY.

Qualities.

It is heavy. 1.
fluid. 2.
cold. 3.
divisible. 4.
volatile* when heated.
white.
brilliant. 5.
opaque.
least tenacious of all bodies.
dilatable by heat.
medicinal.
natural.
mineral.

1. Weight. Nearly fourteen times heavier than water. It is the heaviest known fluid.

2. Fluid. It always retains its fluidity in our tem-

* Volatile, from Lat. vol-*are*, to fly.

perature; but near the poles it congeals, and then is malleable, ductile, and tenacious.

3. Cold. It is the coldest of all fluids, and the hottest when boiling.

4. It is capable of division, by the slightest effort, into an indefinite number of particles, which are of a spherical shape.

5. The peculiar brilliancy of metals has given rise to the term *metallic lustre*.

Uses of Quicksilver.

Quicksilver penetrates and softens other metals, losing its own fluidity, and forming a kind of paste called *amalgam*. This affinity or attraction that it has for other metals, makes it exceedingly useful in separating them from substances with which they are found combined; they are drawn from their ores and unite with the mercury, and the latter being volatilised, the pure metal remains. Quicksilver is easily affected by the atmosphere, and is on this account used in Thermometers and Barometers.* The Thermometer is an instrument constructed in the following manner: a tube of glass, terminating in a hollow ball which contains mercury, is plunged into boiling water, which causes the mercury to expand and rise to a certain height. At this point, which is called boiling heat, the tube is broken off

* Barometer, from βαρ-ος (*baros*) weight, and μετρον (*mĕtron*), a measure. Thermometer, from θερμ-ος (*thermos*) hot.

and hermetically sealed;* the freezing-point is then ascertained and marked, and the intervening space graduated. The Thermometer, by marking the expansion and contraction of the quicksilver, indicates the increase and decrease of heat and cold in the atmosphere.

To form the Barometer, a glass tube, open at one end, and filled with quicksilver, is plunged with its open end downwards into a bowl containing some of the same fluid. Part of the mercury in the tube flows into the vessel, leaving a space to which the air cannot gain access. A vacuum being thus formed, the atmosphere acts upon the mercury in the bowl: when heavy, causing it to rise in the tube, and when light (the pressure being decreased), allowing it to descend. The barometer, by thus showing the weight of the air, indicates the probability of wet or dry weather. For when the atmosphere is light, it no longer supports the vapour and clouds which float in it, and they consequently descend towards the earth; but when the air is more dense, they are borne up, and we have fine weather. The elevation of mountains is also ascertained by means of the Barometer; for as it is known that the rarity of the

* In order to seal any thing hermetically, the neck of a glass tube is heated till on the point of melting, and then with a pair of hot pincers it is closely twisted together, by which means the air is excluded. Hermetically is derived from *Hermes*, the deity of ancient mythology who was thought to preside over the arts and sciences, particularly chemistry.

atmosphere increases in proportion to the ascent, the height is easily calculated.

Quicksilver is also used for coating mirrors. The process is effected in the following manner: a sheet of tin-foil the size of the plate of glass is placed evenly on a smooth block of stone, over this is poured some quicksilver, which is carefully spread upon it with a feather or rubber of linen. Tin, in amalgamating with mercury, quickly forms an oxide of a black appearance: this being removed, more of the fluid is poured upon it. The glass is then held horizontally, and carefully spread over the amalgam, sweeping before it the superfluous mercury, and any more oxide that may have formed. Weights are then placed upon the glass, and after having remained several days, the mixture adheres firmly and forms the mirror.

Vermilion, used in colouring sealing-wax, and the medicine called calomel, are preparations of this metal.

Geographical and Geological Situation of Quicksilver.

Quicksilver is found in the native state, as globules, in the cavities of mines; but it is most frequently combined with sulphur, forming the mineral called Cinnabar, which is of a red colour.

The quicksilver mines of Idria are said to yield annually 100 tons: those of Spain still more; but the mines of Peru are the richest.

The mines of Idria were accidentally discovered

about three hundred years since. That part of the country was then much inhabited by coopers; one of the men, when retiring from work in the evening, placed a new tub under a dropping spring to try if it would hold water, and when he came in the morning he found it so heavy that he could scarcely move it. On examination he perceived a shining, ponderous fluid at the bottom, which proved to be quicksilver. When this circumstance was made known, a society was formed to discover and work the mines from whence the mercury had issued. In some parts of the mine it flows in small springs, so that in six hours as much as thirty-six pounds have been collected; in other parts it is found diffused in small globules.

LESSON XL.

LEAD.

Qualities.

It is heavy. 1.
fusible. 2.
bright when first melted or cut.
malleable.
ductile.
very soft. 3.
pliable.
livid, bluish grey.

It is easily calcined, that is, reduced by heat to a friable substance.
solid.
sometimes amorphous.
sometimes crystallised.
opaque.
mineral.
liable to tarnish. 4.
inelastic.
natural.
It makes a grey streak on paper.
It boils and evaporates at great heat.

1. Heavy. It is eleven times heavier than water; rather heavier than silver.

2. It melts at a much lower temperature than the other metals.

3. It is the softest of all metals.

4. Lead is not much altered by being exposed either to air or water, though the brightness of its surface is soon lost. Probably a thin stratum of oxide is formed on the surface, which defends the rest of the metal from corrosion.

Uses of Lead.

The calx* of lead is the basis of many colours,

* Calx is the dross formed on the surface of lead when fused. This name is applied by chemists to those substances which have been reduced by burning to a friable state. The operation by which this effect is produced is called *calcination*. It is more general now to term metallic bodies when calcined, *oxides*.

which are obtained from it by different degrees of heat. Red-lead and white-lead, so much used in paints, are the calces of lead. They are soluble in oil, are very poisonous, and occasion the ill health to which painters are subject. The oxide of lead also enters into the composition of white glass, rendering it clearer; it is also used in the glazing of common earthenware vessels. Any acid will extract a poison from lead, and therefore the use of it should be avoided in culinary operations. It is employed in glazing pottery.

When rolled between iron cylinders to the requisite and uniform degree of thinness, lead is employed to cover the roofs of houses and churches; but in case of fire, its melting is attended with much danger. It is also used for gutters and pipes of houses, and for cisterns and reservoirs of water, because it does not rust, and is very durable.

The great softness of lead, and the ease with which it is fused, are the properties which have brought it so much into use. The persons who work it are called *plumbers*.* The solder they use as a cement is an alloy of lead and tin, in the proportion of two parts of the former to one of the latter.

Great quantities of lead are consumed in making shot. The metal for this purpose is alloyed with arsenic, to render it more hard and brittle, and capable of assuming a perfectly spherical shape.

* Plumb-*er*, from the Latin plumb-*um*, lead.

Shot are formed by dropping the melted alloy into water from a considerable height, through an iron or copper frame, perforated with round holes, which are larger or smaller according to the required size of the shot. Mixed with antimony, lead is used for printing-types; and with tin and copper, it forms pewter.

Geological and Geographical Situation of Lead.

Lead abounds in England and Wales, particularly in the countries of Derby, Northumberland, Somerset, Cornwall, and Devon. It is plentiful also in Scotland, Ireland, Germany, France, and America. It has lately been imported in such quantities from Spain, as greatly to lower its price in England. It is very doubtful whether it is ever found native; it occurs frequently combined with sulphur, when it is called *galena*.

It is supposed that some of our lead-mines, which are perhaps the most important in the world, were worked by the Romans. When the ore is brought out of the mines it is sorted and washed, to free it from dirt and rubbish; it is then spread out, and the best pieces separated. After the ore, by picking and washing, has been sufficiently cleansed from extraneous matter, it is roasted * in a kind of kiln,

* *Roasting* is the process by which the volatile parts of an ore are evaporated. *Smelting* is that by which the pure metal is separated from the earthy particles combined with it in the ore. This is done by throwing the whole into a

to free it from the sulphur usually combined with it. The next process is to mix it with a quantity of coke, and submit it to the *smelting* furnace. In this there are tapholes, which, when the lead is melted, are opened, to allow it to run in a fluid state into an iron vessel. The dross which floats on its surface is skimmed off, and the metal is taken out by ladles, and poured into cast-iron moulds with round ends. It is then called *pig lead*, and is fit for use.

LESSON XLI.

COPPER.

Qualities.

It is heavy. 1.
tenacious. 2.
very sonorous. 3.
fusible. 4.
elastic. 5.
capable of extreme divisibility. 6.
malleable.
ductile.
compact.
opaque.
orange-brown colour.
mineral.

furnace, and mixing with it substances that will combine with the earthy parts; the metal being the heaviest, falls to the bottom, and runs out by the proper opening in its pure metallic state.

It is sometimes crystallised.
sometimes amorphous.
brilliant.
reflective.
sapid.
nauseous to the taste.
hard.
unpleasantly odorous.
solid.
medicinal.
easily corroded.

1. Heavy. Copper is eight times heavier than water.

2. Tenacious. A wire one-tenth of an inch in thickness, will support two hundred and ninety-nine pounds and a half without breaking.

3. It is the most deeply sonorous of all metals.

4. It is more easily fused than iron, but less so than gold or silver.

5. It is the most elastic metal, next to iron.

6. A grain dissolved in ammonia will give a perceptible colour to more than 500,000 times its weight in water.

The Uses of Copper.

The uses of copper are numerous and important. When rolled into sheets between iron cylinders, it is used to cover the roofs of houses, especially arsenals and manufactories, where there is liability to fire. The bottoms of ships are coppered in order to make

them sail faster, and to prevent shell-fish from perforating the wood. Copper is much used for cooking utensils, but great care is necessary, for should any acid or even water be allowed to stand some time in the vessels, a poison is extracted; but while boiling, this evil does not arise. It is customary, in order to prevent any danger, to line copper vessels with tin. Copper is used in the manufactories of gunpowder, because it does not, like iron, give out sparks by collision. Plates of copper are sometimes engraved with a sharp instrument called a *burin;* sometimes they are corroded with aqua-fortis;* in the latter case, the copper is covered with wax, on which the design is sketched with a pointed instrument, the aqua-fortis reaches the copper just in those places where the wax has been removed by the sketching, and eats into it. Verdigris is a rust of copper, usually made from that metal by corroding it with vinegar. There is a large manufactory at Montpelier in France, where verdigris is prepared in the following manner:—copper plates and husks of grapes are placed alternately one upon another; the latter speedily corrode the surface of the metal. The verdigris thus formed is scraped off as it collects on the copper; it is afterwards dried, and packed in casks or bags. It is chiefly employed in dying, and is a most virulent poison. The alloys of copper are numerous and valuable. Brass is the most important; it is com-

* Aqua-fortis (strong water) is nitric acid diluted with water.

pounded of zinc and copper, in the proportion of three parts of the former to one of the latter. This is a very beautiful and useful substance; it does not rust so easily as copper; it is more ductile than either that metal or iron, and is therefore used in the construction of musical and mathematical instruments, and in clock-work. Sieves and blinds are woven of brass wire of extreme fineness. Brass is used both for purposes of ornament and use. Copper alloyed with tin forms bronze; it is remarkable, that when these two metals are melted together, the compound so produced is heavier than the weight of the two metals taken separately. Bronze is very useful from its being extremely hard, durable, and sonorous; it is fabricated into cannon-balls, statues, &c. The metal of which cannon are made is also an alloy of copper with tin. Bell-metal consists of three parts copper and one tin.

Geographical and Geological Situation of Copper.

Copper is found in Sweden, Saxony, Great Britain, America, and Australia. It was one of the metals earliest known: the Bible mentions workers in brass before the flood.

It is found in great variety of forms; sometimes in masses of pure metal, but more frequently combined with other substances, particularly sulphur. The copper-mines of Anglesea are very productive; they are situated on the top of a mountain, and form an enormous cavity more than 500 yards long, 100

broad, and 100 deep. The ore is obtained from the mine, either by pickaxes or by blasting the rock with gunpowder. It is then broken with a hammer into small pieces, an operation which chiefly employs women and children. After this, it is piled on a kiln, to the upper part of which flues are attached, that communicate with sulphur chambers. The kiln is covered, and the fires lighted in different parts, that the ore may undergo the process of roasting. The whole mass gradually kindles, and the sulphur which is combined with the ore, being expelled in fumes by the heat, is conveyed through the flues to the sulphur chamber. This process occupies from three to ten months, according to the size of the kilns. When the operation is complete, or the ore is freed from the sulphur, it is submitted to the smelting-houses, where, by the intense heat it undergoes, the pure metal is forced off in a fluid state.

LESSON XLII.

IRON.

Qualities.

It is elastic. 1.
ductile. 2.
heavy. 3.
tenacious. 4.
hard. 5.
malleable.

It is liable to rust.
sonorous.
mineral.
fusible.
livid grey colour.
bright.
reflective.
solid.
susceptible of a high polish
cold.
sometimes amorphous.
sometimes crystallised.

1. In the state of steel, it is the most elastic of all metals.

2. Iron is more ductile than gold; it may be drawn into a wire as fine as human hair.

3. It is the lightest of the common metals except tin; between seven and eight times heavier than water.

4. The most tenacious of the metals. A wire about one-tenth of an inch in diameter will support 500 pounds without breaking.

5. Its hardness exceeds that of most other metals, and this is increased by its being converted into steel.

Uses of Iron.

Iron is the most useful of all metals, and man very early became acquainted with its value. Moses speaks of furnaces of iron, and of the ores from

which it was extracted. By means of this metal the earth has been cultivated, houses and cities built, and without it few arts could be practised. Iron is very abundant in nature, but it is always found mixed with some other substance. It is then called *iron-stone.* Sometimes it is combined with clay, at other times with lime, or with flint. In order to separate the iron from its ore, intense heat is required; either pure clay, lime, or silex, remain stubborn in the hottest fires, but when mixed in proper proportions, the one assists in the fusion of the other; therefore there is always thrown into the furnace with the ironstone some earth that will combine with that in the ironstone. The intense heat of the furnace is kept up by means of a continual supply of air, rushing into it from immense bellows, worked by machinery. The lime, clay, or flint, unite and form a kind of slag, which floats on the surface. At the same time the carbon, or pure charcoal of the fuel, aided by the limestone, melts the iron, which, being heavier than the other substances, falls to the bottom of the furnace, and remains there till the workmen let it out by a hole made at the bottom of the furnace, and plugged with sand. When the workman judges that there is a sufficient quantity of the iron fused, he displaces the plug with an iron rod, and the melted iron runs out like a stream of liquid fire, and is conveyed into furrows made in sand, where it cools; the pieces formed in the principal furrows are called sows, those in the smaller furrows branching from

them, pigs. In this state it takes the name of *cast iron*, and from the process it has undergone it is become extremely hard, and having lost its tenacity, it resists the hammer and the file, and is very brittle; it is of a dark grey or blackish colour. It is used for the backs of chimneys, grates, boilers, pipes, railroads, common cannon-balls, &c.

Cast iron is converted into *wrought iron* by a process called *blooming;* it is thrown into a furnace and kept melted by fire; it remains in this situation for about two hours, a workman being continually employed in stirring it, till, by means of the heat of the air in the furnace, the greater part of the carbon is burnt out of it. It thus acquires, by degrees, consistency and tenacity, and congeals into a mass. It is taken out of the furnace whilst hot, and violently beaten with a large hammer worked by machinery; in this manner it is formed into bars of iron. The value of wrought iron in machinery, and tools of all descriptions, is incalculable.

Steel is prepared from wrought iron in the following manner; the bars of iron are kept in contact with ignited charcoal for several hours in earthen crucibles, from which the air is excluded. Steel, if heated to redness, and then suffered to cool slowly, becomes soft and pliable; if plunged while hot into cold water, it is rendered susceptible of a high polish, and acquires such extreme hardness as even to scratch glass, while at the same time it becomes elastic and brittle. Its softness and ductility may, however, be

restored by heating it again and cooling it slowly. Steel varies in colour under the influence of heat: first it assumes a straw colour, then a light yellow; purple, violet, red, deep blue succeed, and last of all a bright blue. These hues indicate the different *tempers* which steel acquires, from that proper for common files, to that requisite for the fine elastic springs of watches. Steel is used for all kinds of edged tools, in which keenness is necessary; it is also much employed for ornamental purposes, on account of the elegant polish which it is capable of taking. In medicine, steel is valuable as a tonic. Waters which pass over iron and become impregnated with it, are called *chalybeate** waters; those of Tunbridge and Hampstead are of this nature. Steel is a combination of iron and a small portion of carbon. Cast iron contains a greater portion of carbon, and is probably saturated with it. Cast iron is converted into wrought iron by burning away the carbon, and wholly depriving it of its oxygen.

Plumbago, or black lead, which is employed in the manufacture of pencils, is an ore of iron, containing nine parts of carbon to one of the metal; sufficient has been found in Cumberland to supply the trade of England, but it is feared that this mine is failing. The bronze colour used in porcelain painting is an oxide of iron. Meteoric stones, which have been the subject of so much conjecture, and which are sometimes believed to be ejected from volcanoes

* Chalyb-*eate*, from χαλυψ (chalyb-*s*), iron.

in the moon, are native iron; there is a fine specimen in the British Museum.

Iron is very valuable from the magnetical properties it may acquire. By these it enables the mariner to steer across the ocean, the traveller to direct his course with safety in the pathless desert, and the miner to guide his researches after subterraneous treasures. The loadstone, or natural magnet, is an oxide of iron; it communicates its power to bars of iron or steel when placed in contact with them. The artificial magnet is now always used, as it possesses and retains all the properties of the loadstone. The qualities which render it useful, are, its attracting iron, and its polarity, or the power by which it points to the poles when freely suspended. One end invariably turns to the north, and the other to the south, except when it approaches the poles; there the directive power ceases altogether, which circumstance constitutes one of the great difficulties in navigating the Arctic Seas.

Geographical and Geological Situation of Iron.

Iron is the most universally diffused of the metals. It is found in every country, in greater or less quantities; but England, France, Sweden, and Russia, are richer in this metal than the other parts of Europe. It is very rarely met with in a native state, but generally as an oxide, or in combination with sulphuric or carbonic acid.

LESSON XLIII.

TIN.

Qualities.

It is heavy. 1.
soft. 2.
malleable. 3.
ductile.
fusible.
white.
opaque.
solid.
brilliant.
very little elastic.
pliable.
easily calcined.
natural.
mineral.
reflective.
sonorous, makes a crackling noise.
dilatable by heat.

1. It is seven times heavier than water; yet the lightest of the ductile metals.

2. It is softer than silver, but harder than lead.

3. Tin may be beaten into sheets the 100th part of an inch in thickness.

Uses of Tin.

Tin is chiefly employed in the manufacture of culinary utensils; they are not, however, made of solid tin, but of what is called *tin-plate*, which is thus prepared. Thin iron plates are first well cleansed, by washing them in water and sand: they are then dipped into melted tin, and afterwards steeped in water acidulated with sulphuric acid. This process causes the tin not only to cover the surface of the iron plate, but to penetrate it, so that the whole mass becomes of a whitish colour. Pins are made of brass wire, tinned. When the pin is formed, a vessel is filled with strata or layers of tin plates between the brass pins; the vessel is then filled with water and some tartaric acid, by means of which the tin is dissolved; after five or six hours' boiling, the pins are found uniformly tinned. It is the zinc of the brass which has an affinity for the tin, and forms the union which takes place. The pins are afterwards polished; they are thrown into a tub containing a quantity of bran, which is set in motion by the turning of a shaft in the centre: the friction which the pins thus undergo renders them perfectly bright. The uses of tin in domestic purposes are very various, particularly when laid over other metals, as in stirrups, buckles, &c. The oxide of tin is used in dyeing.

Tin forms alloys with several other metals. These compounds have been mentioned before; as bell-metal, pewter, bronze. Tin leaves, amalgamated

with mercury, are used for silvering and plating other metals.

Geographical and Geological Situation of Tin.

England, Germany, Chili, and Mexico, produce the largest quantities of this metal. The tin mines of Cornwall were well known to the ancients: and the Phœnicians are said to have traded with the Britons for it long before the birth of our Saviour. Native tin is never found, and its ore is of less common occurrence than that of iron. It occurs as an oxide, or mixed with sulphur and copper; chiefly in veins running through granite and other rocks. When it is taken from the mine, it is broken into small pieces, and streams of water are passed over it, to free it from the earthy particles with which it is intermixed; it is then roasted and smelted, when the metal is poured out into quadrangular moulds of stone, and receives the name of block tin.

LESSON XLIV.

COMPARISON OF METALS.

Gold, a perfect metal, is the most precious.
most compact.
heaviest.

Its weight is between nineteen and twenty times that of water.

SILVER, a perfect metal, is next in value to gold, and more useful; its weight between ten and eleven times that of water.

QUICKSILVER is fluid.
easily volatilised.
immalleable.
Its weight is between thirteen and fourteen times that of water.

COPPER is the most sonorous.
most elastic, except iron.
Its weight is between eight and nine times that of water.

IRON is the most elastic.
most tenacious.
most useful.
most ductile.
Its weight is between seven and eight times that of water.

LEAD is the softest.
most easily fused.
Its weight is between eleven and twelve times that of water.

TIN, next to lead, is the softest of the metals: it dilates most by heat; it is the lightest, its weight being only seven times that of water.

LESSON XLV.

ON METALS IN GENERAL.

Metals are simply elementary bodies, distinguished by being heavier than all other substances ; by possessing a peculiar lustre, which is called *the metallic lustre;* by reflecting light and heat; by their being opaque, fusible, malleable, tenacious, ductile, and generally elastic. Upon this last quality seems to depend their fitness for exciting sound, or sonorousness. Metals are capable of uniting with each other in a state of fusion: this union is called an *alloy.* It is remarkable that by these combinations metals undergo a considerable change in their properties, and acquire new ones not belonging to either of them when not united. Thus the weight of the alloy, or the two metals in combination, is sometimes very different from the weight of both the metals taken separately: an alloy of silver with copper or tin, or one of silver or gold with lead, is heavier than the same quantities of those metals uncombined. Their ductility and malleability are changed and generally impaired, the alloy becoming brittle. This is very remarkably the case with gold and lead when united, the latter of which, even in the trivial proportion of half a grain to an ounce of gold, renders the mass quite destitute of tenacity.

The hardness of metals is varied by combination.

Gold being united with a small quantity of copper and silver, with a minute proportion of the same metal, acquires such an increase of hardness, that these additions are always made to gold and silver which are to be exposed to wear. By a small addition of gold, iron is said to gain so much hardness as to be even superior to steel for the fabrication of cutting instruments.

Change of colour is a common effect of the union of metals with each other. Arsenic, for example, which resembles steel, and copper, which has a red colour, afford by their union a compound which has nearly the whiteness of silver.

In order to ascertain how far the children have retained the knowledge acquired in these lessons, the following questions may be given to them to answer in writing :—

QUESTIONS ON THE METALS.

GOLD.

1. What are the chief qualities of gold?
2. What is its weight?
3. Give a proof of its ductility.
4. tenacity.
5. malleability.

6. Upon what other quality does its malleability depend?

7. What qualities are directly opposed to malleability?

8. What is an alloy?

9. Why is gold alloyed for the purpose of coinage?

10. What metal is used as its alloy? and in what proportion?

11. How are buttons gilt?

12. Describe the manner of forming leaf-gold.

13. In what state is gold found?

14. What is an ore?

15. What is meant by a native metal?

16. In what countries is gold found?

17. What people employ themselves in separating it from the sands of the European rivers?

SILVER.

1. What are the chief properties of silver?

2. What is its weight?

3. What degree of tenacity does it possess?

4. What are the chief uses of silver?

5. Upon what qualities do the uses of silver depend?

6. Describe the operation of plating.

7. What is lunar caustic? and what are its uses?

8. Give a geographical and geological account of silver.

9. Why are gold and silver called perfect metals?

QUICKSILVER.

1. What are the uses and properties of quicksilver?
2. What is its weight?
3. In what respect is it remarkable as a liquid?
4. What effect does heat produce upon it?
5. Under what circumstances does a change in its qualities take place? and what is the change?
6. What is an amalgam?
7. Mention the uses of quicksilver?
8. What are the properties that fit it for a barometer?
9. What for a thermometer?
10. How is a barometer made? and what is its use?
11. How is a thermometer made? and what is its use?
12. What colour is obtained from quicksilver?
13. Where is quicksilver found?
14. What circumstance led to the discovery of the mines of Idria?

LEAD.

1. What are the remarkable qualities of lead?
2. What is its weight?
3. What are the different effects which heat produces on lead?

4. What are the chief uses of lead?
5. Why is it used for reservoirs of water?
6. How are shot made?
7. What is the use of the oxides of lead?
8. What are its alloys?
9. In what state is lead found?
10. What is lead called when found united with sulphur?
11. Where is lead most abundant?
12. Describe the process of roasting and smelting.

COPPER.

1. What are the chief qualities of copper?
2. What is its weight, and what its degree of tenacity?
3. How is it proved to be capable of extreme divisibility?
4. What are the uses of copper?
5. What is verdigris? and how is it made?
6. What is the danger incurred by employing copper in kitchen utensils?
7. What are the alloys of copper?
8. In what respect is brass preferable to copper?
9. Where is copper found? and in what state?
10. Describe the copper mines in Anglesea, and the manner of extracting the metal from the ore.

IRON.

1. What are the chief qualities of iron?
2. What quality does it possess in a higher degree than any other metal?
3. What is its weight and tenacity?
4. What are the different states in which iron is used?
5. How is cast iron prepared?
6. What are its qualities and uses?
7. How is wrought iron prepared?
8. What are its qualities and uses?
9. How is steel prepared?
10. What are its qualities and uses?
11. What is meant by the temper of steel?
12. What is plumbago? and what quality makes it useful?
13. What is the geographical situation of iron? and with what is it found combined?

TIN.

1. What are the qualities of tin?
2. What are the uses of tin?
3. How is it prepared for use?
4. How are pins tinned?
5. What is block tin?
6. Where is tin found?

ON EARTHS.

LESSON XLVI.

LIME.

THE substance called Lime is never found pure in nature, owing to its great affinity for carbonic acid * and for water. All the earths of which lime forms the basis are called *calcareous*.† It is the most universally diffused of all substances, and one of the most abundant; it is computed that it constitutes one eighth of the crust of the earth. In this distribution we have great cause to admire the wise and good providence of the Creator, as the utility of lime in various arts, in agriculture, in manufactures, and in medicine, is very great. Lime, united with carbonic acid, forms common limestone, chalk, marble, &c.; with sulphuric acid, it constitutes gypsum or alabaster; and with fluoric acid, fluor or Derbyshire spar. These are its most interesting combinations with mineral substances. It enters also into the composition of animal matter, as shells, bones,

* Carbon is charcoal in its purest and colourless state; it is most abundant in the vegetable kingdom, and is chiefly obtained from wood. The diamond is the only pure carbon that is known. United with oxygen, carbon forms carbonic acid.

† Calcareous, from the Latin *calx*, lime.

and the hard coverings of insects: our bones contain 8 parts in 10 of lime; and the shells of birds' eggs, 9 parts in 10.

Pure lime is procured from chalk, or limestone, by means of burning. Alternate layers of calcareous earth and fuel are arranged in a kiln; a fire being kindled, the carbonic acid and water become volatilised, and are driven off, leaving the lime pure. In this state it is called *quick lime*, and is white, caustic, acrid, pungent, infusible: corroding and destroying animal matter. When water is poured upon it, it swells, falls into a powder, and gives out great heat. This last operation is called *slacking* the lime. The water combining with the lime becomes solid, and the heat is occasioned by its changing from a fluid to a solid state, for in doing this it parts with some of its caloric. The uses of lime are numerous and important. It is formed into mortar, the cement used in building. The lime being slacked, is made into a paste by tempering it with water; to this is added sand, and sometimes chopped hairs; as it dries, it becomes solid, hard, and durable. Examples have been known of buildings a thousand years old, in which the mortar is as hard as the stones which it unites.

Lime is used as a manure, to loosen soils which are too tenacious, and to render them more friable and capable of receiving vegetable fibres; it also hastens the dissolution and putrefaction of animal and vegetable substances, of which mould is chiefly

composed, and gives it the power of acquiring and retaining moisture, so necessary to the growth of vegetables. Lime is also employed in the manufacture of sugar, to deprive it of a portion of its acid. Tanners use it in removing hairs from the hides, and cleansing them from fat and grease; it is used also in bleaching, and as a flux in the smelting of metals.

Carbonate of Lime.

Lime occurs most frequently combined with carbonic acid in different proportions. These substances are called carbonates of lime. They vary much in appearance, but all agree in the following properties: they readily yield to the knife; neutralise acids, (the characteristic properties of each being destroyed,) and have a weight two or three times greater than that of water.

The most common carbonate of lime is limestone; it occurs in almost every country, and forms hills of some eminence: it is very abundant in England; it is used for making mortar, forming roads, &c. Different kinds of limestone are used in building, as Portland stone, Oolite, &c. The former has been employed in several of the principal buildings in London, as St. Paul's, the Monument, and some of the bridges. Some limestones are soft, when first taken from the quarry, but become hard when long exposed to the air.

Calcareous spar is the purest carbonate of lime; it occurs both amorphous and crystallised, is trans-

parent, shows the double refraction, and takes the form of a rhombohedron, occurring in eight hundred varieties of this figure. Carbonate of lime is often found in stalactites; these are long, pendulous masses, deposited from water loaded with particles of carbonate of lime, which trickle through fissures in rocks, or crevices in the roofs of caverns, &c. The water evaporates, and the particles of lime gradually harden; drop succeeds drop, till a long irregular tube is suspended, often of a most grotesque appearance. When carbonate of lime occurs of a close-grained texture, it is called *marble:* being susceptible of a high polish, it is much used for ornamental purposes, as chimneypieces, pillars, and statuary.

Chalk is another carbonate of lime, not so generally occurring as limestone, but very abundant in the south-eastern counties of England, along which it stretches in a continuous line. It forms hills of a moderate elevation, characterised by their gentle slopes and rounded summits, arising from this substance being of too soft a nature to resist the action of the weather. There are two beds of chalk; the upper one distinguished by containing parallel horizontal layers of flint, with many petrifactions; and the lower, by being destitute of both. Chalk is white, dull, friable, meagre to the touch, adheres to the tongue, is of an earthy fracture, always amorphous and opaque. It is usually dug from pits; but in some parts of Kent the workmen undermine the sides of the hill, then dig a trench, which is filled

with water; this, soaking in, loosens the masses, which consequently fall. Most of the uses of chalk are nearly the same as those of limestone; when freed from its coarser particles, it forms whiting.

Water impregnated with calcareous substances is occasionally deposited on vegetables, clothing them with a stony coat; this incrustation is called *Tufa.*

Sulphate of Lime.

Gypsum is a sulphate of lime; it is much softer than marble, and more easily worked; it is sometimes of a beautiful transparent whiteness, when it is called alabaster, and is made into vases and other ornaments. The gypsum which is very abundant in the neighbourhood of Paris is of a yellowish colour. When heated it pulverises, and water poured over it is quickly absorbed, forming a paste, which dries and hardens very rapidly. This is the Plaster of Paris, so much used for casts, statues, &c. When mixed with a glutinous substance, it forms *stucco* and *plaster.*

When gypsum occurs crystallised, it is called *Selenite.*

Fluate of Lime.

Lime combined with fluoric acid is called Fluate of Lime, or Fluor. It is very abundant in Derbyshire. It is formed into very beautiful ornaments, and is much used in the smelting of the ores of copper.

LESSON XLVII.

SILICA.

A large number of the rocks with which the earth abounds, and a great proportion of compound earthy substances and minerals, have silex for their chief ingredient. It seems to form the solid basis of the crust of the globe, giving firmness and durability to the mountains, by which they have resisted the various revolutions that the earth has undergone. It is found in its greatest purity in *rock-crystal* and *quartz*. It is the basis of almost all the mineral substances, which are sufficiently hard to strike fire with steel. These substances are called *silicious*, from the Latin *silex*, a flint, because flint is almost entirely composed of silicious earth. Silex forms a large portion of granite, and enters in considerable proportion into the composition of slate: it is also the substance which constitutes sand, and generally the shingle of the sea-shore. It is very hard, striking fire with steel, and scratching glass; it has neither taste nor smell; when perfectly pure (in which state it is, however, never found in nature), it is infusible, but when heated with an alkali, it unites with it, melts, and forms glass. In consequence of this property, silica has also been called vitrifiable earth, from *vitrum*, the Latin for glass. It is not affected by any of the acids except fluoric.

Common sand is a granulated silex, generally of a white, red, or yellow colour. In the torrid regions of Africa and Asia, there are immense tracts of desert covered only with sand, so fine and dry as to be moveable with the wind, and forming waves like those of the sea. The wind sweeping the sand from the surface continually, the successive waves form mountains of sand. These are incessantly shifting, and often overwhelm the travelling caravans. Sand is of great utility. It enters into the composition of mortar. It produces the vitrification of glass and porcelain. In agriculture it is valued as a manure; it gives lightness to clayish and heavy soils, and assists in the work of filtration.

Sandstone is formed of grains of silex cemented together, producing a solid rock, though often of a very friable nature.

Common flint contains of silica ninety-seven parts in one hundred. It is generally of a greyish colour, approaching often to black; it is opaque, but translucent at its edges. It strikes fire by collision, and is on this account used in gunlocks. From its being one of the hardest substances in nature, it is often taken as an emblem of firmness or obduracy. It is found principally in beds or strata, in chalk formations. It is used in the manufacture of glass and porcelain, in the construction of buildings and walls, and it also forms excellent roads.

LESSON XLVIII.

ALUMINE OR ARGIL.

This substance obtained the name of Alumine from its forming the base of common alum; and Argil,* on account of its being the constituent of all clays, which are therefore termed *argillaceous* earths. The distinguishing qualities of clays are, that they have an earthy texture, give out a peculiar odour when breathed upon, which has been thence called the argillaceous odour; they adhere to the tongue; are never found crystallised, but sometimes slaty; are generally opaque, and their weight is about twice as great as that of water. When tempered with water, most argillaceous substances become soft, tenacious, and plastic;† but shrink and harden by the application of heat. Alumine is never found pure in nature; but it is considered to be the most plentiful earth next to silex.

Common clay is a nearly equal admixture of alumine and silex; it is found in most countries, and is very valuable in various arts: for these it is peculiarly fitted, as it may be moulded into any form, which it retains unchanged after exposure to heat. The beds of lakes, ponds, and springs, are almost entirely of clay; instead of allowing the filtration of

* Argil, from Latin argil-*la*, clay.

† Plastic, from πλασσ-ειν (plass-*ein*), to form.

water, as sand does, it forms an impenetrable bottom, and by this means water is accumulated in the caverns of the earth, producing those natural reservoirs, whence springs issue and spout out at the surface. Clayey soils, in consequence of their absorbing and retaining moisture, are heavy and sticky. Clay is often used by the poorer classes of society in forming their cottages.

Loam is an argillaceous substance, containing a great proportion of sand, and is generally found upon a bed of sand. It is the substance of which bricks and tiles are constructed; when well baked in a kiln, or in the sun, it becomes very hard and durable. A proof of this is furnished in the existence at the present day of those mighty Egyptian Pyramids, which many suppose to have been the work of the Israelites in their bondage.

Porcelain clay is that employed in our china manufactories; it absorbs moisture rapidly, and becomes very tenacious when kneaded. It is distinguished from other clays by the fineness of its texture, its friability, and meagre touch. A coarser kind, called *Potters' clay*, is used in making common earthenware.

Another description of clay, of a plastic nature, is called *Pipe clay*, from its being used in the manufacture of pipes; it is cast in a cylindrical mould, a wire being afterwards run through it to form the hollow through which the fumes of the tobacco are inhaled; when baked, it becomes hard and white. This clay is also used in extracting grease out of different sub-

stances. *Fullers' earth* is another argillaceous substance, similarly employed.

The soil or mould which covers our fields and gardens, contains more or less of these three substances, alumine, silica, and lime. They occur in very different proportions; a mixture of all forms the best soil, each correcting and keeping within their due proportion the qualities of the other: thus, in a clayey soil filtration is carried on by means of sand, while clay, on the other hand, gives consistency to a sandy soil, and lime loosens the texture of heavy lands, and corrects the coldness occasioned by their retaining water. The fertilising property of our soils, however, greatly depends upon the admixture of decayed animal and vegetable matter.

QUESTIONS ON THE EARTHS.

LIME.

1. Why is lime never found pure in nature?
2. What name is given to the substances containing lime, and from what is the name derived?
3. Name the various minerals of which lime forms a principal part.
4. From what substance is pure lime generally procured?

5. Describe the process.

6. What is the operation of slacking lime, and the effect produced?

7. Name the different uses of lime, with the properties that fit it for those uses.

8. What is a carbonate of lime?

9. Mention the different carbonates of lime.

10. What qualities do they all possess?

11. Describe calcareous spar.

12. What are stalactites? Describe their formation.

13. What is marble, and how used?

14. Describe chalk, its situation, qualities, and appearances.

15. What is calcareous tufa?

16. Name the limestones used in building.

17. What is gypsum, its qualities, and uses?

SILICA.

1. In what minerals is silica found in the greatest purity?

2. Why is it called silica?

3. What are the earths called that contain silica?

4. What other name is sometimes given to them, and why?

5. What are the distinguishing qualities of siliceous earths?

6. What are their chief uses?

7. What is sand?

8. Where does it abound? and to what misfortune are those liable who travel in the countries where it abounds?

9. Describe common flint, and name its uses.

10. In what geological situation is it found?

ALUMINE OR ARGIL.

1. Why is clay called argil? why alumine?

2. What are the distinguishing qualities of alumine?

3. What qualities render it so useful in the arts?

4. Name the different argillaceous earths.

5. Name their various uses.

6. What is loam, its situation, and uses?

7. How is porcelain clay distinguished?

8. What clay is used for the manufacture of common earthenware, and how does it differ from porcelain clay?

9. What clay is used in the manufacture of pipes, and how are they made?

10. What clays are used for extracting grease?

11. Why are clays used for the bottoms of lakes, canals, &c.?

12. What kind of soil does clay form?

LESSON XLIX.

COAL.

Coal may be considered as a mineral, both from its subterraneous situation and the qualities which it possesses ; many circumstances, however, justify the now prevalent opinion that it is of vegetable origin : the following are, perhaps, the most convincing. Carbon, which is the chief constituent of all vegetable matter, particularly wood, composes three-fourths of this substance. Coal is also found in the various stages of mineralisation. Sometimes it possesses a completely fibrous texture and ligneous appearance, even the knots of wood being discernible, whilst the same bed produces specimens of perfect mineral coal. That which preserves most distinctly the character of wood is found at Bovey, near Exeter. In Ireland a standing forest has been discovered at the depth of one hundred feet below the soil. To this we may add the inflammability of this substance ; the numerous vegetable remains and impressions that accompany it ; and that it has never been discovered above the line to which vegetation reaches.

Coal is of a black colour, bright, and frequently iridescent ; the structure is slaty ; it occurs always amorphous ; it is very combustible, a quality which few minerals possess. The places from whence it is taken are called *coal-mines;* they abound in many

parts of England, and have mainly contributed to the wealth of our country. Both the persons employed in the mines, and the vessels which transport the coals, are called *colliers;* the place where the trade is carried on, a *colliery.* The access to coal-mines is generally through a narrow, perpendicular tunnel called a *shaft*, up which the workmen and coals are drawn by machinery. The mines at Whitehaven are some of the most extraordinary in the world. The principal entrance is by an opening at the bottom of a hill, through a long sloping passage which is hewn in the rock, and leads to the lowest vein or bed of coal; the descent is chiefly through spacious galleries intersecting each other, formed by the excavation of the coal, large pillars of which are left to support the ponderous roof. These mines are very deep, and are extended under the bed of the sea, even to where the depth of the water is sufficiently great to admit ships of burden. In these mines there are three strata of coal, which lie considerably apart from one another, and are made to communicate by pits. Miners are frequently impeded in their progress by veins of hard rock called *dykes*, and the coal is seldom found in a direct line on the other side of them; to ascertain its precise situation is often a work of considerable labour and expense. Coal is generally situated at the foot of mountains, and in hollows, which vary much in extent; it rarely lies much above the level of the sea.

Several dangers attend the labour of miners; the

greatest is that arising from *fire-damp*, which is occasioned by the hydrogen gas or inflammable air produced in the mine, and which, when mixed with atmospheric air, explodes with great violence if brought into contact with any lighted substance. To avoid this danger, safety-lamps are used, which were invented by Sir Humphry Davy. They are of a very simple construction, consisting of wire gauze so closely interwoven, that gas of sufficient quantity to cause ignition cannot enter them. Another danger arises from the formation of carbonic acid gas, or fixed air, which, being heavier than the common air, occupies the lower part of the mines, and occasions death by suffocation.

Coal is used to raise the temperature of rooms; to cook food; to supply the fuel for manufactories (particularly where steam is required), and in the working of metals. It furnishes us with the gas so much used, which is the substance called hydrogen, and exists in coal in union with carbon; it is easily driven away or volatilised by heating the coal in a close place, and when caught and preserved, it forms the gas now used to light our streets and buildings: when this has been extracted from the coal, the residue is called *coke*, which is employed where intense heat is requisite.

LESSON L.

GRANITE.

Granite is a compound rock, formed by an aggregation of grains of quartz, felspar, and mica. The proportions in which these component parts occur vary much; but felspar is the predominating, and mica the least considerable, of these ingredients. The grains are also of different magnitudes; when they are large, the granite is of a very coarse texture; but sometimes they are so small, as almost to give the appearance of a uniform mass. These circumstances occasion a great variety in the character of granite. When hornblend occurs in the place of mica, the rock is called sienite. Some felspar is liable to decomposition, and when this is the prevailing substance in the rocks, they yield to the effects of the weather, and become more or less of a rounded form: but when the granite is hard and close-grained, which is more usually the case, they rise in bold prominent peaks, giving grandeur and boldness to the scenery. Granite is found in most countries where there are mountains of any considerable elevation. It forms the lofty Grampian hills in Scotland; and the Logan or rocking-stones of Cornwall are immense blocks of this material. Granite is valuable on account of its great hardness and durability: it is used for mill-stones, troughs, and steps: the

streets of London are paved with it, and it is employed in architecture. Waterloo Bridge, and the new London Bridge, are constructed of granite.

LESSON LI.

SALT.

Salt is a mineral substance, beautifully white, sparkling, and crystalline; it is soluble, fusible, granulous, and of a peculiar flavour called *saline*. There are several varieties of this useful mineral, which are distinguished by the different situations in which they are found. The principal are *sea-salt*, called also *bay-salt*, which is produced from the ocean; the best comes from Portugal; salt drawn from brine-springs; and *rock-salt*, which is dug out of the earth. Amongst the most extensive salt-mines hitherto discovered are those at Wielizka, a picturesque little town situated on the sides of a gentle valley, about eight miles from Cracow, formerly the chief city of Poland. The traveller who visits these subterraneous deposits of salt, being furnished with a guide and two lamp-bearers, is let down a shaft of about 150 feet by a rope. At the depth of 90 feet he arrives at the rock of pure salt, which is of a dingy soot colour, here and there glistening by the light of the lamps. The swing is now abandoned, and the ear is assailed by the busy sound of spades, mattocks, and wheelbarrows, in every direction. This is the *first*

floor of a large cavern, containing in different parts a stable for twenty horses, quantities of salt, some in bare masses, some in casks ready to be hoisted to the surface, stores of implements for the miners, &c. This excavation is about 100 feet long and 80 broad (besides the stable), and about 20 feet high. From hence a long gallery, 12 feet high by 8 broad, leads towards the interior of the mine, where lateral avenues branch off in various directions, each named after some Austrian prince or princess, and resembling more in appearance the avenues of a subterraneous palace, than the passages of a mine. A flight of steps conducts down another hundred feet to the *second floor;* in this descent the bed of salt is interrupted by a narrow stratum of pure clay; sometimes by a mixture of salt and the same earth; these strata are, in places, very curiously curved, as though a rolling wave had been arrested in its course, and preserved in its original form. The miners are here found at work, some hewing pillars of salt from the rock, some cutting them into masses for home consumption, and some stowing the masses in barrels for exportation. The cavern on this floor is rather smaller than the first; it consists of one spacious hall, and has no pillar to support the roof.

Proceeding on his subterranean journey, the traveller arrives at a wooden platform, from whence he looks down upon an abyss, which the simple lights of the conductors fail to illuminate, though the spars of the mineral reflecting the rays of light produce a

novel and beautiful effect. When princes or other great personages visit the mines, a chandelier of crystal salt, hanging in the centre, is furnished with 150 lights, which display a stupendous cavern, having the appearance of a castle in ruins; at the bottom are some rows of seats, rising like the benches of a theatre; opposite to these is an orchestra: here, on such occasions, a small band plays a few airs of slow and simple music, which has a most singular effect, and harmonises well with the surrounding scene. Long galleries and flights of steps, all spacious enough to allow free course to the fresh air, lead deeper and deeper in the saline rock; the scene now and then is varied by a cavern full of workmen, and some along the galleries, wheeling their little carts full of salt, each with its lamp in front. On the *fourth floor* there is a little subterraneous lake, about 80 feet long and 40 broad, over which illustrious personages are ferried on rafts of fir-logs lighted by numerous flambeaux. Here terminates the bed of *green salt*, the most common sort, and easiest to be cut. The next to it is called *spica salt*, which is harder and more close-grained, and next succeeds a white and finer-grained variety. This part of the mine is 700 feet below the surface of the earth: 300 feet beneath this lies the finest crystal salt, which is reached by long flights of steps and inclined planes. The cavern in which it is found is sufficiently spacious for a regiment of soldiers to perform their manœuvres in it. This is the deepest part of the mine, the

air is quite pure, rather cooler than that of the open day, but much warmer than it is about half-way down. The return is through a different series of corridors and caverns. On the third floor is a simple tomb of salt, with the name of the late Emperor of Austria inscribed with letters of wood neatly gilt. On the second floor is a large saloon with all the implements of mining, and the mode of letting them down with men and horses exhibited in transparency. On the first is a chapel presenting an altar, statue of the Virgin, crucifix, and figures of Casimir I. and his wife, all cut out of the solid salt; before the chapel is a small pulpit in the Gothic style. To visit the whole of this extraordinary and extensive mine, with all its galleries and caverns, no less a distance than 300 miles must be traversed.

The salt used in England is chiefly obtained from the sea, or salt brine-springs. The saline water is admitted into open shallow trenches, and being exposed to the sun, or artificial heat, the water is evaporated, and the salt is precipitated in a crystalline state.

The conservative properties of salt render it invaluable for household purposes, and for preserving meat during voyages; and its stimulating properties give a relish to food and help digestion. When fused, it is used in glazing pottery; it improves the whiteness and clearness of glass, and gives hardness to soap; it is used by the dyer in fixing colours; also sometimes as a manure.

It was employed in all the Jewish ceremonies, being emblematical of purity and incorruptibility. Our blessed Lord calls his disciples the salt of the earth; thereby signifying to them that having, by divine grace, their own hearts purified, they are to exercise by precept and example a purifying influence on the hearts of others.

LESSON LII.

SLATE.

Slate is a mineral substance; it is never found crystallised, but generally of a foliated structure: it is either of a grey, bluish, or blackish colour, often streaked by a different tint from that of the ground; it is opaque, dull, compact, and brittle. It consists chiefly of alumine, with a small quantity of silex. It is dug out of quarries: when first taken from them, it is comparatively soft, but becomes hard by exposure to the air. It is used for writing upon, for whetstones, and for roofing houses. In order to ascertain its fitness for the latter purpose, it is weighed as soon as it is excavated, and is then put into water for some days; if after being well dried it is found to have increased in weight, it is laid aside as unsuitable for the purpose, the trial having proved that it was porous, and consequently absorbent. Such slate would not only allow water to pass through it, and so destroy the wood-work of

buildings, but it would also be liable to be covered with lichens and moss, in consequence of the moisture which it retains. If its quality is ascertained to be good, it is split into thin plates for roofing. The tiles are fastened to the rafters by pegs driven through holes, which have been previously made in them; the edge of one is laid over the other, in the same manner as the scales of fishes. Slate which is dark-coloured, compact, and solid, is the best adapted for writing upon. In order to prepare the slate for this purpose, it is rendered smooth with an iron instrument, and it is then ground with sandstone, and slightly polished. That which is softer and more friable, is used for pencils. Since the repeal of the duty upon slate it has been extensively used for many purposes; such as flooring of warehouses, shelves, mantel-pieces, formation of cisterns, and covering of houses in exposed situations. The principal slate quarries in Great Britain are in Caernarvonshire. Those belonging to Mr. Pennant (formerly Lord Penrhyn's), near Bangor, employ about 1500 men and boys, and are the most extensive and valuable in the empire.

LESSON LIII.

CORAL.

Corals are the secretions made by one of the lowest class of animals, called polypi, inhabiting the deep;

they sometimes assume the forms of branches of the most beautiful appearance; sometimes they resemble beads strung in a necklace, while others present a more consolidated mass: but all are perforated with pores more or less minute, which are the habitations of the little architects.

Among the various phenomena of the natural world, there are perhaps none more calculated to excite astonishment and admiration than the vast coral reefs that rise up from the deep, and at times even constitute islands. They are produced from a calcareous matter which exudes from the coral worm, and hardening, forms at once their habitation and their mausoleum. This creature is of the class of zoophytes, the lowest grade of animal life, the link between the animal and the vegetable kingdom. They work only under water, so that the coral reefs never rise above the level of the sea; and when the tide retires, the rock appears dry, compact, rugged, and perforated; but when the returning waters wash its sides, a most interesting spectacle of active life is presented, countless myriads of various shapes and colours protrude themselves from the orifices, and the whole edifice seems teeming with life and animation.

The coral ceases to grow in height when the worm is no longer exposed to the washing of the sea; the work is then commenced at the sides, and other parts rise in succession, till they reach the same height, and form a level surface at the top, with steep precipitous sides. In this manner, and by

such insignificant agents, atom deposited upon atom, the solid rock is at length produced; upon this the sea deposits sand, mud, and decayed sea-weed; these prepare for mosses and lichens, which in their turn produce a soil for more perfect vegetation; till at last the island thus formed becomes a fit residence for man.

As these rocks are constructed beneath the surface of the sea, they present no beacon to warn the mariner of their existence, and thus render navigation in those seas in which they abound exceedingly dangerous.

LESSON LIV.

GUTTA PERCHA.

This useful substance is the gum of a tree growing in Singapore and Borneo. The word *gutta* means gum, and *percha* is the Malayan name for the tree which chiefly yields this gum. The natives tap the tree when it is in the state to produce the largest amount of this its peculiar juice.

Gutta percha is brought to England in a shapeless lump; it is reduced to a pulp by lacerating machines, is then purified by water, which is combined with other substances according to the preparation necessary for its future destination; it is pressed into

sheets and different forms by rollers, and little is afterwards required to fit it for the particular purpose to which it is to be applied.

The numerous valuable qualities of gutta percha fit it for a great variety of uses. Its toughness (which differs from that of caoutchouc) and the facility with which it can be softened by heat render it peculiarly apt to receive, and permanently to retain, any form that can be given to it; but its being so readily affected by heat prevents its being available except for cold purposes. Its toughness, and the ease with which it is converted into a tenacious cement, make it very valuable in the different processes of book-binding. Its impermeability to water has caused it to be used for the soles of shoes, and it is taking the place of lead in the conveyance and stowage of water; with this great advantage, that the injurious effect produced by the action of water upon the metal is avoided. From its power of resisting the most potent chemicals, it is of the greatest service to the chemist; and it is substituted much for glass in the conveyance of their preparations, especially muriatic acid, whereby the expense occasioned by breakage is prevented. Its applicability to various purposes in the laboratory is great, as for syphons, funnels, &c., and in surgery for bandages for wounds, stopping teeth, &c.

The various domestic purposes to which it is applied can scarcely be enumerated; and its plastic nature enables it to be moulded into any form, and

makes it fit for a great variety of vessels; also for ornamental purposes, as picture-frames, trays, inkstands, &c., and different embossed articles. The advance in the trade of gutta percha proves the increasing appreciation of its value. The first specimen was brought to England in 1843, and in the following year 230 pounds were exported to Great Britain from Singapore; in 1848 the exports amounted to as much as 1,700,000 pounds, and it was computed that no less than 300,000 trees were destroyed to obtain this supply.

ON THE SENSES.

LESSON LV.

The children having been already exercised in determining by which of the senses they discover the presence of any quality, may be led to consider more fully the senses themselves. The first two lessons are drawn out for the use of the teacher: the substance only of the others is given.

TEACHER. Do you understand how you gained the knowledge of various qualities?

CHILDREN. By our senses.

TEACHER. How do you know when a thing is red or blue?

CHILDREN. By sight.

TEACHER. How, if you were blind, could you form a correct idea of colour? What other means is there of gaining this knowledge?

CHILDREN. None.

TEACHER. True; and to ascertain this point, a blind man was once questioned as to what notion he had of scarlet: he said he thought that it must be like the sound of a trumpet. It is obvious that he had no correct idea of a quality discoverable by the sight, and he could only compare it with one that he had acquired through the medium of another sense. Can you tell me the reason why persons born deaf cannot speak?

CHILDREN. They cannot imitate sounds, because they never heard any.

TEACHER. Since, then, deaf persons have no correct ideas of sound, nor blind persons of colour, how did we acquire our ideas of sound and colour?

CHILDREN. By the means of the senses of seeing and hearing.

TEACHER. How, then, do we suppose our minds become stored with ideas?

CHILDREN. By the exercise of our senses.*

TEACHER. Yes; and if you had once had the

* It is probable that children would not at once arrive at this conclusion. The teacher must, in that case, lead them to it by easy questions.

idea of a dog formed in your mind, by seeing such an animal, when a dog is mentioned you can recall the idea, and fancy one immediately, as if it were present; your mind will also perform the same operation when a quality is spoken of, which you had previously seen in some object. Again, if you see a dog unlike any you have observed before, you compare it with the species with which you are acquainted, and mark the difference between them. If I say that I have some green paper, cannot you immediately conceive the colour of which I speak?

CHILDREN. Yes.

TEACHER. Did you, then, exercise your sight?

CHILDREN. No.

TEACHER. How, then, could you have the idea of green?

CHILDREN. We remembered it.

TEACHER. By what means did you first obtain the idea?

CHILDREN. By seeing something green.

TEACHER. What power of the mind do you exercise in recalling an idea?

CHILDREN. Our memory.

LESSON LVI.

FEELING OR TOUCH.

TEACHER. What part of your body is the organ of touch?

CHILDREN. It seems all over our body.

TEACHER. Tell me some parts that do not possess the sense of feeling.

CHILDREN. Our hairs, nails, teeth.

TEACHER. And in other animals, what parts are found destitute of sensation?

CHILDREN. The hoofs, horns, claws, feathers, wool, hair, &c.

TEACHER. What word would you use to express the absence of sensation? What syllable prefixed to a word gives it a negative meaning?

CHILDREN. *In*.

TEACHER. Well, what word will express the absence of sensation?

CHILDREN. Insensibility.

TEACHER. The parts then that you have named are insensible, and, with the exception of these, the sense of feeling exists everywhere throughout the body; but what part of it is particularly adapted, by its form, to become the organ of the sense?

CHILDREN. The hand.

TEACHER. Tell me what qualities we can discover in objects by this sense?

CHILDREN. That they are hard, soft, rough, smooth, long, short, sharp, blunt, round, square, cylindrical, conical, heavy, light, fluid, liquid, dry, wet, hot, cold, &c.

TEACHER. By what general term would you express such qualities as round, square, conical, &c.?

CHILDREN. By *shape*.

TEACHER. By what general term would you express such qualities as large, small, &c.?

CHILDREN. By *size.*

TEACHER. By what general term would you express such qualities as rough, smooth, &c.?

CHILDREN. By *kind of surface.*

TEACHER. By what general term would you express such qualities as hard, soft, fluid, tenacious, &c.?

CHILDREN. By *kind of substance.*

TEACHER. By what general term would you express such qualities as heavy, light, &c.?

CHILDREN. By *weight.*

TEACHER. Now arrange the qualities which you discover by your feeling under five general heads, *i.e. shape, size, kind of surface, kind of substance, weight.*

The children having performed this exercise, the teacher may mention the following facts.

TEACHER. The quickness and accuracy of the sense of feeling is, we find, much increased by exercise, as is exemplified in blind persons, the defect of whose sight is frequently compensated, in a great measure, by an exquisite sensitiveness of touch. Bats also appear to possess this sense in a remarkable degree. They have been observed, even after loss of sight, and with their ears and nostrils stopped, to fly through intricate windings and passages, without striking against the walls, and also to avoid lines and cords placed in their way. The expanded membrane that serves them for wings is probably the seat

of this delicate sense of feeling, which so admirably fits them for their nocturnal and dark abodes. The palpi, or feelers of insects, possess the same quality very acutely, and this enables them to explore the surface of bodies in search of food, and warns them also of the approach of danger.

The class should be required, at the conclusion of the lesson, to draw up some account of this sense, mentioning where it resides, what qualities fall within its cognisance, and to recapitulate any incidental information received during the lesson.

LESSON LVII.

SIGHT.

The eyes are the organs of sight, and are beautifully adapted for the office they have to perform. They are so constructed as to allow us to see things near, or at a distance; to confine ourselves to the inspection of one object, or to take in at once a large sphere of vision. The part of the eye which admits the light may be expanded or contracted, according as the rays are more or less powerful. The fact is remarkably exemplified in the eyes of the cat and of the owl. Indeed nothing affords a more striking proof of the kind providence of God than the beautiful adaptation of the eyes of animals to their peculiar

modes of life; those of moles, fishes, and birds, are remarkable illustrations of this fact.*

Of all the senses, that of sight is in most frequent and continual exercise. It fills the mind with the greatest variety of ideas, which it gathers not only from the objects of nature and of art, but from the writings of the wise and good of all ages.

The qualities we discover by this sense are, transparent, semi-transparent, translucent, opaque, glimmering, bright, dark, sparkling, dull; and the various modifications of colour, size, and shape. Many may be ascertained either by touch or sight; as those of size, form, kind of surface, and substance.

LESSON LVIII.

HEARING.

The ears are the organs of this sense. In many animals the ear has externally the form of a trumpet, and is well adapted for gathering sound and bringing it to a focus; in man it contains many convolutions and channels, which receive the vibrations of air in every direction, and convey them to the part called the drum, which is the actual seat of this sense.

The formation of the ears of animals is beautifully accommodated to their peculiar habits of life. In

* The Teacher should here fully explain to the class the circumstances referred to, and give other similar instances.

beasts of prey the trumpet part is inclined forwards, easily to catch the sound of those they are pursuing. But animals whose chief means of protection is flight have these organs turned backwards, that they may be readily apprised of the approach of their enemies.

The ears are the medium through which all sensations of sound reach the mind; without them, we should be deprived of the advantages of verbal instruction, the pleasures of conversation, and the charms of music.

The motion of the parts of a body, or the collision of one body against another, occasions a vibration in the air, which is similar to the effect produced on water when a stone is thrown into it. Circle succeeds circle, till the power of motion is exhausted; and just as any light substance within the influence of these undulations is agitated by them, so when our ear is within reach of these vibrations of air, the sensation of sound is produced.* The chirping note of the cricket is occasioned simply by the constant friction of a little membrane against its wings. When two bodies are rubbed or struck together, we may in most cases be able to determine by the sounds emitted, the nature of the substances brought into contact. Very different sounds are occasioned by the collision of metals to that which wood gives out;

* This account may appear, at first sight, above the comprehension of children; a class, however, which had gone through the preceding exercises, was found fully capable of understanding it.

and the sound produced from hollow bodies is very unlike that resulting from solid ones. There are various kinds of sounds; as shrill, deep, grating, harsh, loud, soft, harmonious, sweet. Animals produce different sounds. The cat mews, the dog barks, the lion roars, the ass brays, the cow lows, the horse neighs, the rook caws, the goose cackles, the cock crows, the fly buzzes, the bee hums. Man speaks, laughs, cries, shouts, groans, whistles, sings.

LESSON LIX.

SMELL.

The nose is the organ of this sense; its cavities are lined with a thin membrane supplied with nerves connected with a principal one, which is essential to the perception of smell.

By means of this sense we derive all our ideas of odour. Though not so important to man as the other senses, yet it adds much to his pleasure; and to many animals it is essential, directing them in the search of their food. The scent of dogs is peculiarly fine, and on this account they are employed in the chase.

Odour is produced by exceedingly small particles called effluvia, which escape from odorous bodies; these diffuse themselves in the atmosphere, and

whenever they reach the olfactory nerves they occasion the sensation of smell. Heat promotes the escape of these particles, which are of a volatile nature; hence, when the sun shines brightly, the flowers are more fragant.

LESSON LX.

TASTE.

The mouth is the organ of taste. The skin within the mouth is finer and more delicate than that of the rest of the body, it is supplied with a great number of blood-vessels, and covered with innumerable papillæ. Sapid bodies, however, before they excite the sensation of taste, require to be moistened by the saliva. In graminivorous animals the papillæ are defended from the action of the stiff bristles of grass and corn by a strong skin, which being perforated, allows the dissolved juice to reach the seat of taste. The principal qualities discoverable by the taste are bitter, sweet, acid, pungent, acrid, luscious. There are many others, which derive their names from the substances in which they exist; as salt, spicy, &c.

Many animals have some one of the senses in great perfection, but in none are they all found in the same degree as in man.

ON SOLUBILITY.

LESSON LXI.

INTRODUCTORY REMARKS.

Lessons on objects would be well followed up by instruction on qualities with which the children are familiar. This idea is well worked out by Mr. Tegetmeir, who purposes publishing a series of such lessons; the following, which is copied with a few alterations from one of his, will explain what is here recommended.

LESSON ON SOLUBILITY.

The Teacher developes the ideas for which he afterwards gives terms by means of simple experiments. In the first he fills half full with water three glass tubes; he then adds to one a pinch of Epsom salts, to another a few grains of sugar, to the third some powdered marble, and shakes each for a few moments.

TEACHER. I wish you to describe the changes which have taken place in the mixtures.

PUPILS. 1st. The salts and the sugar have disappeared. 2nd. Melted in the water. 3rd. Dissolved in the water. The marble remains the same.

TEACHER. Right; the salt and sugar have dissolved in the water; the marble is not dissolved. Do you know what those substances are termed that dissolve in water?

PUPILS. Soluble.

TEACHER. What are those termed which do not dissolve?

PUPILS. Insoluble.

TEACHER. Tell me the names of several soluble bodies.

PUPILS. Sugar, Epsom salts, gum, salt.

TEACHER. Tell me some that are insoluble.

PUPILS. Marble, stone, wood, tin, slate.

TEACHER. What has become of the sugar that dissolved?—is it destroyed?

PUPILS. No, it is in the water.

TEACHER. How do you know that it is in the water?

PUPILS. We can taste sugar when it is dissolved in our tea, or in water.

TEACHER. Would it be useful to give a particular name to a liquid that has dissolved any substance, in order to distinguish it from another that has not any substance dissolved in it?

PUPILS. Yes.

TEACHER. Such liquids are called *solutions:* what, therefore, is formed by the experiments made?

PUPILS. A solution of Epsom salts in water, and another of sugar in water.

TEACHER. Is there a solution of marble formed?

PUPILS. No; for the marble would not dissolve.

TEACHER. Does the water, or the sugar, or both together, form the solution?

PUPILS. Both together.

TEACHER. A liquid used to dissolve a solid is termed a *solvent.* What can we say of water?

PUPILS. It is a solvent of Epsom salts, sugar, &c.

Teacher takes two equal portions of Epsom salts and places each in a tube, with equal quantities of water. One is left undisturbed, whilst the other is heated in the flame of a spirit-lamp. The pupils are required to state what result they observe.

PUPILS. The water that has been made hot has dissolved the salts very quickly, and also in greater quantity. (The experiment should be made with the sugar also.)

TEACHER. What would you say of the effects of hot liquids on soluble bodies?

PUPILS. Hot liquids dissolve substances more quickly and in greater quantities than cold ones.

TEACHER. This is generally, but not invariably, true. There are some bodies upon which cold and hot water has the same effect. Common salt is an example.

Teacher makes another experiment; placing two equal quantities of sugar in water, allowing one to remain undisturbed, and shaking or stirring the other. Pupils to tell the result observed.

PUPILS. The sugar in the shaken tube dissolves first.

TEACHER. Try and explain why this is so.

PUPILS. When the tube is shaken, every part of the solid is affected by the solvent which dissolves it; but when the sugar lies at the bottom, the water at the top does not help to dissolve it.

Teacher then places a large lump of sugar in a spoon and puts it into a tumbler of water, holding it near the top; and then, placing the tumbler between the pupils and the light, requires them to say what they observe.

PUPILS. Little wavy lines fall from the spoon.

TEACHER. Can you tell what causes this? Consider what is happening to the sugar.

PUPILS. It is dissolving.

TEACHER. What, then, is being formed?

PUPILS. A solution of sugar.

TEACHER. What becomes of the solution, as it is formed?

PUPILS. It is that which we see falling through the water.

TEACHER. Right; but why does the solution sink in the water?

PUPILS. It must be because it is heavier than water.

TEACHER. It is so; every solution formed by a solid in water is heavier than water. Knowing this, can you tell me why men swim more easily in the sea than in fresh water, and even more easily still in the Dead Sea?

PUPILS. Sea water is a solution of salt, and being heavier than fresh water, a man would not so easily sink in it.

Teacher next places a quantity of common salt in a tube, and pours over it about twice its weight of water, shaking it for some time,—then asks what has happened.

PUPILS. Part of the salt is dissolved, and part is left,—the water does not dissolve it all.

TEACHER. You are correct; water will not dissolve more than one-third of its weight of salt; and when it refuses to dissolve more, it is said to be *saturated*. What kind of a solution is then formed?

PUPILS. A saturated solution.

TEACHER. Water, as we have seen, will dissolve more of some bodies, as Epsom salts, when it is heated. If we were to heat a cold solution of Epsom salts, what do you think would happen?

PUPILS. It would then dissolve more salts, showing that it would not be saturated by the same quantity of salt as it was when cold.

Teacher puts some powdered sealing-wax into two tubes, and pours into one cold water, into the other spirits, and then shaking them, asks the pupils to say what difference they observed in the two.

PUPILS. The sealing-wax has dissolved in the spirits and not in the water.

TEACHER. Is sealing-wax a soluble or insoluble body?

PUPILS. It is both; soluble in spirits, insoluble in water.

TEACHER. What kind of liquid is a solvent to sealing-wax, and other resinous bodies?

PUPILS. Spirits.

Teacher repeats the last experiment, substituting gum for sealing-wax.

PUPILS. The gum, contrary to the sealing-wax, dissolves in the water, but not in the spirit; it is also soluble and insoluble.

TEACHER. It is so: but when no particular solvent is named, it is always understood to be water: hence, in ordinary language, gum is said to be soluble; sealing-wax insoluble, the solvent, water, being understood. India-rubber is an example of a solid, insoluble in all ordinary liquids, but soluble in coal-tar, naphtha; the solution thus obtained is used for making waterproof (Macintosh) clothing, by employing it to cement together two thin layers of cloth.

The pupils then should be required to mention all the new terms they have learnt, or any like them; as soluble, insoluble, solve, solvent, solution, dissolve, dissolving, solubility, insolubility, saturated.

TEACHER. Do you observe a resemblance in these words?

PUPILS. Yes: they all, except saturated, have *solve* or *solu* in them.

TEACHER. The meaning of that root, as it is called (for it is like the root of a plant, the part from which the other parts spring), is to *loose;* it comes from a Latin word *solvo*, to loose—the *v* being changed into *u:* the word soluble then means, being able to be loosed, or to have particles separated by the action of a liquid. What would insoluble mean?

PUPILS. *In* stands for not, therefore it means not soluble.

TEACHER. I wish you now to sum up the various parts of the lesson, so as to connect the whole together.

Bodies that are capable of *dissolving* are called *soluble;* those not capable of doing so, *insoluble.* When we speak of a body possessing *solubility*, we say it will *dissolve.* A liquid that dissolves a solid is termed a *solvent;* and a *solution* is a *solid dissolved in a liquid.* When the solution will hold no more of the substance dissolved in it, we say it is *saturated.*

TEACHER. These terms are sometimes used metaphorically—that is, applied to what is of a different nature; try and remember some examples.

PUPILS. To solve a question.

TEACHER. Which means, to take it to pieces or unloose it. What similar use of any of these terms do you recollect?

PUPILS. Dissolution of partnership.

TEACHER. What does this mean?

PUPILS. That it is unloosened; the partners are no longer united together.

TEACHER. And what do we mean when we call death a dissolution?

PUPILS. That the body crumbles to pieces; its parts are all loosened or separated.

VOCABULARY.

AROMATIC, derived from the Greek ἄρωμα, arōma: spice having a pungent spicy smell.

ADHESIVE, derived from the Latin ad-hær-ĕre, to stick to: composed of particles which not only unite together, but attach themselves to other substances, causing them to stick together;—thus the particles of gum have a strong mutual cohesion; it also easily attaches itself to paper and other substances, causing them to hold together.

AFFINITY, derived from the Latin affin-*is*, related: the tendency which some bodies have to unite with others.

ABSORBENT, derived from the Latin absorb-ĕre, to suck up; sucking up liquids. An absorbent substance must be also porous, for if there were no pores, the liquid could not enter the substance.

AGGREGATION, derived from the Latin aggreg-*are*, to collect together in one flock. A collection of things brought together in one.

ARGILLACEOUS, derived from the Latin argilla, clay: partaking of the nature of clay, or consisting principally of clay.

ALLOY, an inferior metal mixed with one more precious: or the compound of two metals.

ASTRINGENT, derived from the Latin ad-string-ĕre, to bind to: binding, contracting.

AMORPHOUS, derived from the Greek α (a) not, and μορφη (morphe) a form: without any regular form.

ACIDULATED, derived from the Latin acid-*ulus*, slightly acid: made slightly acid.

ACRID, from the Latin acri-*s*, sharp: hot, or sharp to the taste.

ANNEAL, to heat glass after it is blown, that it may not break.

AMALGAM, the combination of mercury with any other metallic substance.

AQUA-FORTIS signifies literally strong water, but is applied to a weak nitric acid.

ALKALI, a substance which, uniting with acids, neutralises their acidity: it derives its name from a plant called kali, from the ashes of which alkaline substances are procured.

ATMOSPHERE, derived from the Greek ἀτμος (atmos) vapour, and σφαιρα (sphaira) a globe or sphere: the air that surrounds our globe is composed of oxygen and nitrogen.

BRITTLE, easily broken: hard substances only are brittle.

CONGEAL, derived from the Latin con, together, and gel-*u*, cold; to turn from a liquid into a solid by the influence of cold.

CIRCLE, a circle bounded by a curved line, which is equally distant at every point from the centre.

CIRCULAR, in the form of a circle.

CONE, a solid bounded by a flat circular surface called the *base*, and a curved surface tapering to a point, called the *apex*.

CONICAL, having the form of a cone.

CALCINED, burnt in a fire and reduced to a calx, or friable substance.

CULINARY, derived from the Latin culina, a kitchen: belonging to the kitchen.

CHALYBEATE, derived from the Greek χαλυψ (chaly-*bs*) iron: impregnated with iron or steel.

CORROSIVE, derived from the Latin rod-*ĕre*, to gnaw; having the power of eating away anything.

CONTAGION, derived from the Latin con, together, and tan-*gere*, to touch: something proceeding from body to body, by which disease is communicated.

CONCAVE, the inner curve of a hollow sphere.

CONVEX, the outer curve of a sphere.

CONSERVATIVE, derived from the Latin con, together, and serv-*are*, to keep: having the power of preserving or preventing decay.

CAUSTIC, derived from the Greek καυστικος (causticos), burning: having the power to destroy the texture of parts by burning or eating them away.

COHERE, derived from the Latin co, together, and hær-*ĕre*, to stick; to stick together.

CALORIC, derived from the Latin cal-*or*, heat; heat.

COLLISION, derived from the Latin collis-*us*, struck together: the act of striking two bodies together.

COMPACT, firm, solid, close.

CARBON, derived from the Latin carbo, charcoal: the pure inflammable part of charcoal.

CARBONIC ACID, carbon united with a certain portion of oxygen.

CALCAREOUS, derived from the Latin calx, lime: consisting principally of lime.

COMPONENT PART, derived from the Latin con, together, and pon-*ĕre*, to place: a part forming with others a compound body.

CYLINDER, derived from the Greek κυλινδω (kylindo), I roll: a solid bounded by one curved surface and two flat ends.

CYLINDRICAL, having the form of a cylinder.

DUCTILE, derived from the Latin duc-*tilis*, capable of being drawn out in length.

DECOMPOSITION, the separation of the particles of a compound body.

DILATABLE, derived from the Latin dilat-*are*, to extend: capable of being expanded.

DENSE, close, thick: the opposite to rare.

DILUTED, derived from the Latin dilu-*ĕre*, to wash: having been made thinner or weaker.

ECONOMICAL, derived from the Greek οἰκονομία (oikonomia), household management: relating to the management of a family.

ELEMENT, a substance not compounded, having but one constituent part.

EMOLLIENT, derived from the Latin moll-*is*, soft: having the power to soften.

EXPORTED, derived from the Latin ex, out, and port-*are*, to carry: to carry out of the country.

EXOTIC, derived from the Greek ἐξω (exo), without: not produced in our country; particularly applied to plants.

EVAPORATE, derived from the Latin *e*, out from, and vapor, vapour: to pass off in a vapour.

EXCRESCENCE, derived from the Latin ex, out, and cresc-*ĕre*, to grow: something growing out of another body, not useful to it, and contrary to the common order of production.

EXHALE, derived from the Latin ex, out, and hal-*are*, to breathe: to send out vapours or fumes.

ELASTIC, having the power, when bent or stretched, of returning to its original position.

EFFERVESCENT, derived from the Latin effervesc-*ĕre*, to boil up: bubbling up with internal commotion.

EDIBLE, derived from the Latin ed-*ere*, to eat: fit for food, eatable.

FRAGRANT, having a sweet scent.

FLUID, derived from the Latin flu-*ere*, to flow: having parts easily separable, and flowing about.

FUSIBLE, melting in fire.

FRIABLE, easily crumbling.

FOLIATED, derived from the Latin foli-*um*, a leaf: composed of leaves, or laminæ.

FRACTURE, derived from the Latin fract-*us*, broken; the appearance of a mineral when broken.

FRAGILE, derived from the Latin frang-*ere*, to break: easily broken or injured.

FLEXIBLE, derived from the Latin flex-*us*, bent: easily bent.

FRICTION, derived from the Latin fric-*are*, to rub: the act of rubbing two bodies together.

FARINACEOUS, derived from the Latin farina, flour: mealy, of the nature of flour.

FILTRATION, derived from the Latin filtr-*um*, a colander; the process of passing a liquid through the interstices of another body.

FERMENTATION, derived from the Latin ferment-*um*, leaven; internal commotion in the particles of a body: plants undergo fermentation when they decompose.

GLUTINOUS, derived from the Latin gluten, glue: tenacious, viscid.

GLOBULE, derived from the Latin glob-*ŭlus*, a small globe: small globe or sphere.

GRAMINIVOROUS, derived from the Latin gramen, grass, and vor-*are*, to eat: feeding on grass.

GRANULOUS, derived from the Latin granŭl-*um*, a little grain; separating into small particles or grains, as sand.

GENERIC, derived from the Latin genĕr-*a*, kinds; relating to a genus, or kind of things.

GRADUATED, derived from the Latin gradu-*s*, a step; marked by a regular increase of degrees.

HORIZON, derived from the Greek ὁριζων (horizon) bounding; the line that bounds our view.

HORIZONTAL, in the same direction as the horizon.

HERMETICALLY sealed, so sealed as entirely to exclude the air.

HYDROGEN, derived from the Grek ὑδωρ (hydor) water, and γιννατιν (gen-*naein*) to produce: the lightest gas: with a certain portion of oxygen it forms water.

IRIDESCENT, derived from the Latin irid-*escere*, to be-

come like a rainbow: shining with the colours of the rainbow.

IMPALPABLE, derived from the Latin in, not, and palp-*are*, to feel: not to be perceived by touch.

IMBRICATED, derived from imbric-*are*, to cover with tiles: arranged in the manner of the tiles of the house.

IMPORTED, derived from the Latin in, into, and port-*are*, to carry: carried into a country.

IMPRESSIBLE, derived from the Latin in, and press-*us*, pressed; easily receiving and retaining an impression.

INDIGENOUS, derived from the Latin indig-*ĕna*, native: the natural production of the country. This term is applied to vegetables, as native is to animals.

INSIPID, derived from in, not, and sap-*ere*, to savour; having but little flavour.

INCOMBUSTIBLE, derived from in, not, and combust-*us*, burned: not to be consumed by fire.

INTERSTICE, derived from the Latin inter, between, and stit-*um*, placed: small space between the different parts of the body.

IMPREGNATED, filled with any quality or thing.

INCISION, derived from the Latin incis-*us*, cut in: a cut or wound made by a sharp instrument.

IMPERVIOUS, derived from the Latin in, not, per, through, and via, a way: presenting no passage. A substance is impervious to a liquid when it presents no pore or passage by which it can enter.

IGNITED, derived from the Latin igni-*s*, fire; having been kindled or set on fire.

INFUSION, derived from in, into, and fusus, poured: a liquid in which something has been steeped to draw out its properties.

LIQUID properly signifies that which has been melted; anything which we drink, or which forms into drops. Air is a fluid. Water is both fluid and liquid; when we speak of it as a stream or current, it is properly called a fluid

but when we speak of it as passing from a congealed to a dissolved state, it should properly be called a liquid.

LAMINA, a thin plate.

LAMINATED, formed of thin plates or laminæ.

LATERAL, derived from the Latin latera, sides: at the side.

LIGNEOUS, derived from the Latin lign-*um*, wood: made of wood, or having a woody structure.

LUBRICIOUS, derived from the Latin lubric-*us*, slippery: slippery, smooth.

LAYER, that which is spread over a substance.

MAGNIFYING, derived from the Latin magn-*us*, great, and fi-*eri*, to be made: making things appear larger than they actually are.

MALLEABLE, derived from the Latin malle-*us*, a hammer: capable, when beaten, of great extension without the particles being separated.

MALEFACTOR, derived from the Latin male, badly, and factor, doer: a criminal, an evil-doer.

MATURITY, derived from the Latin matūr-*us*, ripe: ripe, or having arrived at its most perfect state.

MARINE, derived from the Latin mare, the sea: belonging to the sea.

MEAGRE, dry and harsh to the touch; a term applied to earthy minerals, as chalk.

METALLIC, composed of a metal, or of the nature of a metal.

NATIVE, derived from the Latin nat-*us*, born: growing naturally in a country. When applied to a metal, it means that it is not mixed with any other substance.

NUTRITIOUS, derived from the Latin nutr-*ire*, to nourish: containing much nourishment.

NEUTRALISE, derived from the Latin, neut-*er*, neither: to destroy the distinguishing qualities of anything. The compound of an alkali and an acid has not the qualities of either, both being neutralised by their action upon each other.

NITROGEN, a gas: united in certain proportions with oxygen, it forms atmospheric air.

NITRIC ACID, nitrogen, united with a certain proportion of oxygen.

NITRATE, nitric acid united with another substance.

OXYGEN, derived from the Greek ὀξυς (oxys), acid, and γενναειν (gen-*naein*), to produce: a gas; united in certain proportion with oxygen, it forms the air; with hydrogen, water.

OXIDE, that which is united with oxygen.

ODOROUS, derived from the Latin odor, a smell: having a smell.

OVAL, derived from the Latin ov-*um*, an egg: having the form of an egg.

OLEAGINOUS, derived from the Latin ole-*um*, oil: oily.

ORE; a metal is termed an ore when united with another mineral substance.

OPAQUE, derived from the Latin opāc-*us*, dark: dark, not admitting any light to pass through.

PONDEROUS, derived from the Latin pond-*us*, a weight: heavy.

PORTABLE, derived from the Latin port-*are*, to carry: easy to carry.

POLARITY, the property of turning towards the poles.

PLIABLE, derived from the French pli-*er*, to fold: easily folded into plaits. A young twig is flexible, linen is pliable.

PULVERABLE, derived from the Latin pulv-*is*, dust: capable of being reduced to a powder or dust.

PERFORATED, derived from the Latin perfor-*are*, to bore through: pierced with holes.

PLASTIC, derived from the Greek πλασσειν (plass-*ein*), to form: capable of being moulded into any form.

PETRIFACTION, derived from the Latin petra, a stone, and fac-*ere*, to make: turned into stone.

PARALLEL, derived from the Greek παρα (para), by the side of, and ἀλληλων (allelon), each other: running in the

same direction with another thing, and always keeping at the same distance from it.

PERFECT, when applied to a metal, signifies that it does not lose any of its weight by fusion.

POROUS, derived from the Greek πορος (poros), a passage; full of small pores or holes. All bodies are more or less porous, but the quality is only attributed to those in which it is obvious.

PUNGENT, derived from the Latin pung-*ere*, to prick: warm to the taste.

PROCESS, derived from the Latin process-*us*, a going forward: a regular course by which anything is done.

PERPENDICULAR, derived from the Latin perpendicul-*um*, a plumb-line: in the same direction as a plumb-line, hanging freely.

PENDULOUS, derived from the Latin pend-*ere*, to hang: hanging suspended.

QUADRANGULAR, derived from the Latin quatuor, four, and angul-*us*, an angle: a form having four angles.

REFLECTIVE, reflecting or giving back an image: this quality depends upon brightness.

RESERVOIR, derived from the Latin reserv-*are*, to keep: a place where anything is kept in store.

RARITY, thinness as applied to fluids: the opposite to dense.

ROASTING, the process by which the volatile parts of a mineral are evaporated.

RHOMB, derived from the Greek ῥομβος (rhombos), a rhomb: a surface bounded by four equal straight lines; its opposite angles are equal, but not right angles.

RHOMBOHEDRON, derived from the Greek ῥομβος (rhombos), a rhomb, and ἑδρα (hedra), a base: a solid bounded by six rhombs, any one of which may be its base.

STRATUM, derived from the Latin strat-*um*, laid: a bed or layer.

SUPPLE, easily bent in any direction.

SMELTING, the process by which the pure metal is sepa-

rated from the earthy particles with which it is combined in the ore.

SILICIOUS, derived from the Latin, sil-*ex*, flint: consisting principally of silex or flint.

SECRETION, derived from the Latin secret-*us*, separated: that which is separated from any other substance. Tears are an animal secretion; the honey in flowers is a vegetable secretion.

SOLUBLE, derived from the Latin solv-*ere*, to loosen: melting in a liquid.

SOLVENT, having the power of dissolving things.

SOLUTION, that which contains anything dissolved.

SPHERE, derived from the Greek σφαιρα (sphaira), a globe or sphere: a solid bounded by one curved surface, which is equally distant in every part from the centre.

SPHERICAL, having the form of a sphere.

SOLID, filling up space: in this sense it is opposed to hollow.

SOLID, having particles adhering closely together: in this sense it is opposed to fluid.

SONOROUS, derived from the Latin son-*us*, a sound: capable of producing sound.

SUMMIT, derived from the Latin summ-*us*, highest: the top or highest part.

SAPID, derived from the Latin sap-*ere*, to savour: having a flavour.

SPARKLING, bright in parts and not over the whole surface.

SATURATE, derived from the Latin satur, full: to fill anything till it can receive no more.

SEMI-TRANSPARENT, derived from the Latin, semi, half, trans, through, and par-*ens*, appearing; presenting an imperfect passage to the rays of light, so that objects do not appear clearly through.

TRANSPARENT, derived from the Latin trans, through, and par-*ens*, appearing: yielding a free passage to the rays of light, so that objects appear through.

TRANSLUCENT, derived from the Latin trans, through,

and lux, light: yielding a partially obstructed passage to the rays of light, so that light only appears through.

TENACIOUS, derived from the Latin, tenax, holding: having particles uniting firmly together. Gum being tenacious, the particles cannot easily be separated, and on this account it acts as a cement; glue, being more tenacious, acts as a still stronger cement.

TUBULAR, derived from the Latin tubul-*us*, a small tube: having the form of a hollow cylinder.

TOUGH, capable of being bent or extended without breaking.

TARTAR, a hard substance deposited on the sides of a cask during the fermentation of wine.

TARTARIC ACID, tartar combined with a certain portion of oxygen.

TRIANGLE, derived from the Latin tres, three, and angul-*us*, an angle: a form that has three angles.

TRIANGULAR, having the form of a triangle.

TRANSMITTED, derived from the Latin trans, across, and mitt-*ere*, to send; sent from one person or place to another.

VACUUM, derived from the Latin vacu-*us*, empty: space completely unoccupied.

VELOCITY, derived from the Latin velox, swift; speed, swiftness.

VISCID, derived from the Latin visc-*us*, bird-lime: glutinous, tenacious.

VITRIFIABLE, derived from the Latin vitr-*um*, glass, and fi-*eri*, capable of being converted into glass.

VOLATILE, derived from the Latin vol-*are*, to fly; passing or flying off naturally by evaporation.

UNCTUOUS, derived from the Latin unct-*us*, anointed; fat, clammy, oily.

THE END.

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